The Journal

OF THE

Royal United Service Institution.

VOL. X. 1866. No. XL.

Evening Meeting.

Monday, April 9th, 1866.

CAPTAIN E. GARDINER FISHBOURNE, R.N., C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 19th March and the 9th April, 1866.

ANNUAL.

Brooker, G. A. C., Capt., R.N. 1*l.*
Graham, O., Lieut. H.M. Mad. Staff Corps. 1*l.*
Pryce, J., Capt. late Glamorganshire Mil.
Barrington, J. T., Roy. Artillery. 1*l.*

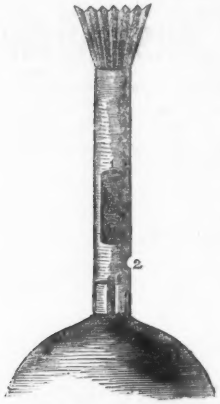
The CHAIRMAN: Captain Norton, who I suppose was almost the first person, at least if not the first, one of the earliest persons to draw attention to the subject of rifles and the use of rifled shot, has sent for the Museum and exhibition, a percussion hand grenade for house defence. He shows his great ingenuity in all such matters. He had the misfortune to be born some fifty years before his time. Had it not been so he would have been a very great man.

CAPTAIN NORTON'S PERCUSSION GRENADE FOR HOUSE DEFENCE.

(*Dedicated, by permission, to General Sir Hugh Rose, G.C.B., Commander of the Forces in Ireland.*)

The fuze grenade is not good for house defence, because when the fuze is lighted the grenade must be thrown, or got rid of, as it would

otherwise burst in the hand and destroy the person. My percussion grenade has no fuze to be lighted, and can be thrown at any time. A daring assailant could pick up the fuze grenade and throw it back; my grenade could not be thrown back with effect. The grenade can be made to fire with a percussion cap if so required. In using revolvers for house defence, the person is necessarily exposed to the fire of the assailants, but in using percussion grenades, the person need not be exposed, as the grenade may be allowed to slide through a temporary spout downwards and outwards.



1. Leaden bolt for pulverizing glass tube.
2. Hole for inserting glass tube holder.

Directions for Use.

When the grenade is about to be used, the winged tube is held slanting downwards so that the leaden bolt within it slides back and leaves the touch-hole open for the insertion of the glass tube igniter; then holding the winged tube perpendicular, the leaden bolt rests upon the glass tube igniter, and on the grenade being thrown out of a window, the shock of falling on the ground pulverizes the glass tube and fires and explodes the grenade.

Annexed is a drawing of the winged tube containing the glass tube igniter, and which is screwed into the iron grenade.*

ON PROJECTILES.

By Michael Scott, Esq., C.E.

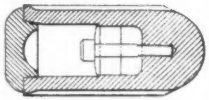
With the permission of the meeting the author proposes on the present occasion to confine his observations mainly to a class of projectiles which may be said to occupy an intermediate place between spherical shot and elongated rifle bolts.

In the year 1862 the writer published a pamphlet† in which he explained a principle whereby the want of homogeneity in elongated projectiles might be obviated, and in which he stated that the centre of gravity being corrected, and the projectile made symmetrical, it would not deviate from the true line of flight, even although not rotating upon its axis.

* They can be obtained at Mr. Calderwood's, Gunmaker, Sackville Street, Dublin.

† On Projectiles and Guns. By Michael Scott, C.E. Clowes and Son, Charing Cross.

N°1. Elevation.



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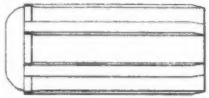

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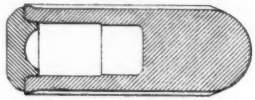
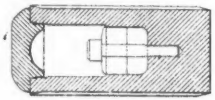


N°1. Section.

PROJECTILES

Referred to in the Paper by

Michael Scott Esq^re C.E.



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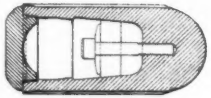

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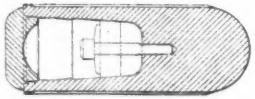


N° 5.

Scale One Inch to the Foot.

J. Jobbins

The experiment had never been tried, and, considering that it would be very interesting to know the result, the writer applied to the Secretary of State for War, and after an extended correspondence with the department, permission was obtained to have a few projectiles tried.

The projectiles referred to, represented by the drawings (see Plate xv), were designed by the author in that year, and the trials took place at Shoeburyness in 1863. The projectiles were found to be defective in certain particulars, the most important being the want of strength in the hollow part of the shot and in the arrangement for correcting the centre of gravity. The author having had no experience of the explosive force of gunpowder naturally underrated it, and the result was, that when fired with high charges, the metal of several of the projectiles broke, and in the whole of them, the arrangement for correcting the centre of gravity gave way.

Moreover, as will hereafter appear, from theoretical considerations, the complete bearing of which were not perceived until after these projectiles were designed, they were imperfect in form—the forward end being either flat or hemispherical, and the backward end having a swell. The gun from which these projectiles were fired was a smooth-bore, 6½ inches in diameter, but unfortunately the bore was not true, being wider at the muzzle than it was further down about the trunnions, so that a projectile which passed easily into the muzzle jammed hard near the trunnions, and it required the united efforts of a number of men to send the shot home. Unfortunately, also, the first projectile which was fired broke in the gun and scored the chase. Under these conditions it was not to be expected that perfect results would be obtained; nevertheless the experiments did establish points of some importance. Disregarding the projectiles which broke in pieces, the first shot (see Plate, Fig. 1) that was fired weighed 104 lbs., the charge was 16 lbs., elevation 5°, the range 1,346 yards, the atmosphere was still, the lateral deviation was unfortunately not measured, but was supposed to be about 4 yards from the line of aim. This shot did not turn over during flight, and ricochetted in a straight line for a great distance.

In loading with the next projectile, it jammed in the gun near the trunnions so hard as to become immovable, and the experiments had to be discontinued, and the gun was sent to Woolwich to have the shot withdrawn. Some months later the experiments were resumed. It was a stormy day, with a high wind blowing across the range so strongly that the author suggested that the experiments should be postponed; but the Assistant Secretary of the Ordnance Select Committee stated that, in estimating the accuracy, allowance would be made for the force of the wind, and the experiments proceeded.

The second shot (Fig. 2) weighed 81·3 lbs., the charge was 12 lbs., the elevation 5°, the range 1,449 yards, the deflection to the left 40 yards, the initial velocity 1,333 feet. As the metal of this shot broke, little information can be obtained from the experiment.

The third shot (Fig. 3) weighed 83·7 lbs., the charge was 14 lbs., the elevation 5°; range 1,391 yards, initial velocity 1,345 feet, the

lateral deviation 27 yards left. This shot did not turn over during flight, but it oscillated, and the range was deficient.

The fourth shot (Fig. 4) weighed 94 lbs.; it was flat headed; the charge was 14 lbs.; the elevation 5°; range 1,512 yards; deflection 29 yards to the left; initial velocity 1,280 feet. This shot did not turn over in flight, and went with comparative steadiness, but chiefly owing to the great resistance of the flat end, and the fact that the initial velocity was not so high as it should have been, the range was limited.

The fifth shot (Fig. 5) weighed 107·7 lbs., charge was 14 lbs., elevation 5°, range 1,433 yards, lateral deviation 24 to the left, initial velocity 1,230 feet. A piece broke off this shot, which, of course, affected the flight.

From these experiments, imperfect as they are, results of some importance have been obtained; for example, it was held to be impossible to fire from a smooth-bore gun an elongated projectile, which would not turn over during flight; this has been accomplished, and, if in the case of one projectile, the principle may be considered as established; secondly, it will be observed that, allowance being made for the wind and the imperfections previously referred to, greater inaccuracy might have been anticipated, for, with a range of 1,391 yards, the shot grazed 27 yards to the left—the direction in which the wind was blowing; and with a range of 1,512 yards, 29 yards to the left; the deviation being what would be due to the difference of range.

Again, having regard to the small diameter of the gun in proportion to the quantity of powder, the initial velocities are satisfactory, for it has been said that a charge of 14 lbs. is more than can be beneficially burnt in a 6·5 inch gun. This quantity has been stated to be a full charge for a 7-inch gun, and to be in the same proportion the charge should be only 12 lbs. for a 6·5-inch gun. As compared with results obtained with larger guns, something would also be due to the inferior area of surface acted upon by the propelling force; for example, this surface, which in the 6·5 gun is only 33·18 square inches, is in a 7-inch gun 38·48.

The principal deficiency in the projectiles was want of range, accounted for in the case of the flat-ended shot chiefly by the great resistance, and in the case of the others by the oscillation; and the author, therefore, proceeded to investigate the effect of different forms of ends, and to inquire into the nature and causes of the oscillatory motion observed.

It has been stated that in order that an elongated non-rotating shot, moving in a resisting atmosphere, should not deviate from the true line of flight, amongst other elements, it ought to be perfectly symmetrical. This is true, so far as relates to the surface on which the air impinges; for should the forward end of the shot be not symmetrical, then it is evident that the pressure upon the surface would not be equally diffused. It would be greater on one side than on the other, which would cause the shot to deviate from the true line of flight.

But it appeared that the effect would be modified by variations in the form of the surface on which the air impinges. Take, for example,

a hemispherical and a flat end. In the case of the first, every part of the surface will have its influence, whereas in the case of the flat end it will be different, for it seems to the author that practically it is the edge of the cylinder which is important.

FIG. 1

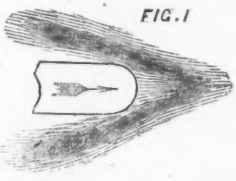
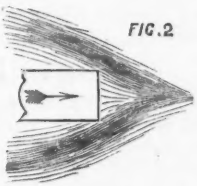
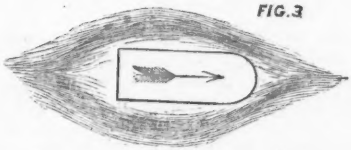


FIG. 2



The diagrams represent the supposed action of the air upon the two forms. With respect to the first, the influence of a projection on one side, in increasing the resistance, will be obvious. With regard to the second, it is believed that there would be a cone of air comparatively stagnant, and little motion across the face; but it will be seen that there is a very great motion across the edge of the end, and, therefore, any irregularity of form here would produce important results, which would be modified by another cause to be subsequently referred to.

FIG. 3



At high velocities the air outside the supposed cone is driven off laterally from the projectile, and may be assumed to flow into the space behind the projectile somewhat as shown in the diagram (Fig. 3), and as the after part of the shot is thus moving in a partial vacuum, it is obvious that perfect symmetry of that part is not of the importance it has been by some assumed to be.

The effects of the wind of a passing ball shows the lateral dispersion of the air, and as a familiar illustration of the vacuous space left, may be mentioned, the case of a stick passed rapidly through water, when it is seen that an empty space is left. The fact stated by Colonel Thiroux that the velocity of revolution of rifled shot is not diminished to the extent which might be anticipated, seems to confirm the view that the shot moves in a very attenuated atmosphere. A practical conclusion might be arrived at from this, namely, that continuous ribs in rifled shot would not meet with greater resistance than studs; and as the bearing surface in the former case would be greater, the continuous ribs might have an advantage.

An important source of error in considering the flight of projectiles

has arisen from assuming that the conditions are the same in the cases of large and small shot. This appears to the author to be a great mistake; for before similar conditions can exist, and similar effects be produced, it would be necessary that the elements of length, diameter, area, and the velocity with which the projectiles are moving, should each vary in some simple ratio, which is impossible.

For example, take two projectiles—one for a musket, one for a large gun.

Suppose each moves through 100 feet in a given period of time. Each projectile has, therefore, displaced a column of air 100 feet long and of its own diameter, and this space has to be re-occupied and filled with air again.

Supposing that the projectile had been moving inside a tube, the opening for the admission of air to fill up this space would be directly as the area of the projectile, but in moving through the atmosphere the condition is different, because the air flows in from the sides as well.

Hence it follows that the opening for the air to flow in, varies as the sum of the area of the end and the circumference of the sides; but this opening does not vary as the quantity of air required to flow in behind projectiles of different sizes. It does not increase so rapidly as the quantity of air to be supplied, and hence, with a given velocity of flight, the back part of a large projectile is moving in a much more attenuated atmosphere than a small projectile. All this shows the incorrectness of arguing absolutely from musket balls up to large projectiles.

The part of the projectile which specially requires to be symmetrical is that part of the forward end upon which the air impinges, and over which it moves. This in a hemispherical end is a large portion of the whole surface, whereas in a flat end the intense action is confined to the extreme edge. In the case of the flat end, the air appears to be dispersed to the greatest extent, and, therefore, not only will this form meet with the greatest resistance from the air, but it will tend to produce a more perfect vacuum behind it.

The next point proposed for consideration was the nature and causes of the oscillation observed in the projectiles designed by the author.

The oscillation is supposed to be produced as follows: assume an elongated shot with a spherical end—when fired, if from any cause (gravity) the back end of the shot tends to droop, there is nothing to check it until it comes in contact with the air, by which time it will have acquired a certain velocity, and it will, therefore, pass through some space beyond the position in which it might have rested before the downward motion is checked. Consequently, having passed the line of quiescence, it is exposed to an upward pressure sufficient to produce upward motion, and thus it continues to oscillate in the vertical plane.

Another motion which the oscillation of the tail tends to produce may be called the plunging of the shot bodily. The cause of this appears to the author to be as follows: when the tail of the shot passes out of the true line of flight, the pressure of the air on the head

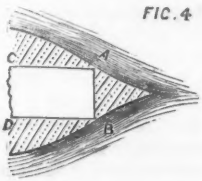
of the shot is greater on one side than the other. If at the lower side, the shot tends to rise bodily; if at the upper side, to fall; and if the shot does not turn over, a plunging motion is produced.

Turning to the forward end of the shot, it will be obvious that the form of end least likely to check the oscillation would be the hemispherical, and the form most likely to check it would be the flat.

It follows, therefore, that were regard to be had solely to the steadiness of the projectile, the best form would be the flat end; but this form we know offers greater resistance than any other. The object, therefore, is to combine the steadiness produced by the flat end with the diminished resistance arising from a modified form.

In dealing with the question of symmetry it was assumed that in the case of a projectile moving with high velocity there was a space of a conoidal form filled with comparatively stagnant air.

FIG. 4



It is assumed that the pressure will be greatest in the centre, diminishing gradually towards the sides.

It might, therefore, be possible to add to a flat-ended shot a bow of a conoidal form, as shown in the sketch, without materially increasing or diminishing the resistance. In the same way the body of the shot might be enlarged as shown in the sketch.

Further, the conoidal form of bow in advance of the line A B would be attended with disadvantages; for, first, it removes the centre of gravity in the direction of the length, further back in proportion to the length, thereby increasing the tendency in an uncorrected shot to turn over.

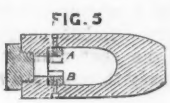
Secondly. The steadying influence of the flat end is lost, and the part of the shot where greatest strength is required is made weak.

The part, therefore, in front of the line A B may be removed.

It has been shown that the additions C A—D B may be made to the projectile without a proportionate increase in the resistance, and as this would give a larger capacity of shell and a heavier shot, this lateral addition may be made with advantage, and the form of the shot becomes that shown in the figures 5 and 6.

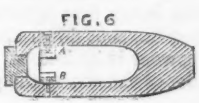
Elongated shot for smooth-bore gun.

FIG. 5



Elongated shot and shell for 9-inch smooth-bore gun.

FIG. 6

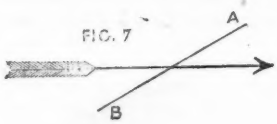


It has been stated that the form of end least likely to check oscillation in the shot would be the hemispherical, and the form most likely to check it would be the flat end. This depends upon a principle of resistance discovered by Mr. Froude.

Without entering upon the subject more fully, it will be sufficient to state that Mr. Froude has found, first, that in the case of a plane moving through a fluid in the direction at right angles to its surface, the pressure is symmetrically distributed.

Second, that in the case of a plane moving through a fluid obliquely, the pressure is greater against the leading side of the plane at A than it is against the following side at B.

FIG. 7



Now the first is the case of a flat-ended shot following the line of the trajectory, and the second is the case of the same shot moving at an angle to that line; and hence, if a flat-ended shot moves out of the true line, an increased pressure would be brought to bear upon the advancing side, which would tend to force back that side, and tend to bring the shot into the true line. Any deviation from the true line would therefore immediately be met by an altered resistance tending to prevent such aberrations, and consequently the flat-ended shot tends to remain in the line of the trajectory, and not parallel with the axis of the gun; but this effect would not take place with the spherical end.

From what has been stated, it would appear to follow that it is questionable if some forms which have been adopted are the best for projectiles.

Moreover, in the case of shot intended to be fired against iron plates, the pointed form appears to be objectionable for another reason, that the point would be smashed and the debris of broken metal interposed between the body of the shot and the plate, thereby reducing the influence of the blow; whereas in the form proposed by the author the point is removed, and the shot will combine the punching effect of the flat end with the bulging effect of the spherical.

It will be obvious that, before one could estimate the practicability of employing elongated projectiles fired from smooth-bore guns, several other points would have to be carefully considered, and it is proposed now to advert briefly to these.

In the case of spherical shot fired from a smooth-bore gun, with the ordinary windage, the effect is supposed to be as follows:—The powder being first ignited at the upper side, a pressure is produced forcing the shot down upon the chase of the gun. Subsequently, when the powder is ignited at the lower side and the shot resting on the bottom of the chase, the gas escaping more freely through the windage

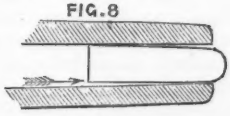
at the upper side of the shot, the pressure is greater at the lower side, and the shot is forced against the upper side of the chase.

In addition, the motion of the shot will be affected by the centre of gravity not being in the centre of the shot, and by friction. In the case of elongated projectiles fired from smooth-bore guns it is different; for, as the whole of the powder is ignited before the shot leaves the gun, and as it is guided in its passage by the chase, it does not appear that the irregularity in the ignition of the powder would affect the accuracy.

The conditions in the case of an elongated projectile are quite different from those of a spherical shot. In order to see this, let us trace the action throughout. Suppose the powder ignited as before at the upper side, the gas would rush out along the upper side of the shot, tending to press it down against the bottom of the chase; but the surface to resist this pressure, which in the sphere was only a point, is in the elongated shot a line of considerable length. Therefore, although guns are damaged by this action in the case of spherical shot, it does not follow that they would be affected in the case of the elongated shot. Then, suppose the whole of the powder is ignited throughout the whole depth of the charge, the tendency would be for the gas on the lower side to raise the shot; but if the shot were raised, the pressure would immediately be increased at the upper side; and as this inequality of pressure can exist for only a very short distance from the tail of the shot, the head would hardly be affected; not so in the case of the sphere, where the whole semi-diameter is exposed to the lifting action of the gas, with nothing to resist it, because what in the elongated shot is a long line, in the sphere is a point.

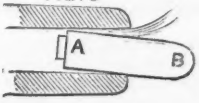
What has been stated would be applicable to a shot which was not moving forwards; but when the tremendous velocity of projection is taken into account, the resistance of the air in front would combine with the pressure of the gas behind to make the shot move parallel with the chase.

FIG. 8



We have now to consider how the shot will be affected at the moment that it issues from the muzzle of the gun. Take the case as

FIG. 9



shown in the sketch (Fig. 9). The forward end of the projectile is deflected downwards by the pressure of the escaping gas on the upper side, but to counteract this there would be the superior pressure against the lower part of the back end, in addition to the pressure on the forward end, which tends to keep the projectile from deviation.

As it may be said that the pressure of the expanding gas on the upper side of the shot would act behind the centre of gravity, and thus tend to depress the back end of the shot, it should be remembered that to counteract this there would be the upward pressure against the lower edge of the plug.

Further, it is well known that gas of high tension expanding into the atmosphere can exercise but very little pressure, because the great bulk of the power is absorbed in producing its own expansion.

Again, the tremendous momentum of the shot at the moment of its leaving the gun (being then at its maximum velocity) operating to keep it in a true direction, and the extreme minuteness of the period of time to which the shot could be exposed to the action of the escaping gas, should be considered.*

In the case of the projectiles which were fired and which did not break, as the difference in range can be accounted for by other causes, it does not seem that the escape of the gas affected the accuracy, and this with a gun which was bored wider at the muzzle than it was further down the chase; but even supposing a bad effect were produced by the escape of the gas at the moment the shot left the gun, a simple remedy would be to place a ring of soft metal at the after end of the projectile, which would be expanded by the force of the discharge to fit the chase. This was in fact the arrangement adopted in one of the early forms of the author's proposed projectiles.

It seemed to the author reasonable to infer that if the resistance were diminished by a modification of the forms, such as is represented in the drawings, and if the hollow part of the projectile and the arrangements for correcting the centre of gravity were made sufficiently strong to resist the force of the explosion, very superior results would be obtained; and with this view, and considering that this system might be specially applicable to naval broadside guns, the author offered his plans to the Admiralty, stating that he was willing to carry on the experiments at his own expense. The authorities, however, did not think it advisable that any experiments should be made, and as it is impossible for a private individual to carry out experiments with large ordnance, the author regrets that he is unable to place before the Institution more perfect results, nor can he of course hope to prove the truth of a system by the firing of half a dozen shots.

Assuming that a range equal to the rifled projectile is not obtained with the smooth-bore projectile, the advantages over spherical pro-

* Suppose the velocity at the muzzle of the gun to be 1,600 feet per second, and suppose the action of the expanding gas to be limited to the time the shot would pass over 3 inches—that is $\frac{1}{6400}$th of a second; further, suppose that the pressure of the expanding gas was equal to $\frac{1}{10}$th of the pressure before issuing from the gun, and that it acted on the whole length and breadth of the projectile, the result would be a deflection of the shot of $\frac{1}{800}$th of an inch.—M.S.

jectiles would be greater accuracy, increased capacity of shell, and superior strength.

As compared with the rifled elongated projectiles in the experiments, there was a deficiency of range, but with slightly increased initial velocity, which would make the penetrating power as great at close quarters.

As the projectiles do not rotate, there would be no lateral deviation from that cause, and straight ricochet would be obtained.

There being only one trajectory* as against two in the case of the rifle, with an unstable platform and the object aimed at in motion, it is believed that as great accuracy would be obtained from the smooth-bore.

The smooth-bore would have the advantage of simplicity in the gun, and it is believed it could be more readily and more quickly loaded; the gun would be durable, and neither gun nor projectiles liable to derangement or injury. Spherical shot, as well as grape and case, could also be fired from the smooth-bore, which, if fired from a rifled gun, would speedily damage the rifling.

The figures (5 and 6) represent smooth-bore shot and shell constructed on the principles which have been enunciated. They may be constructed of cast-iron or of steel.

The drawings represent those of cast-iron.

For naval purposes it would probably be desirable to have projectiles of both metals, the one to be used against armoured ships, the other against ordinary vessels. The conoidal part of the head of the projectiles would be turned in the lathe; the centre of gravity be corrected by the two pieces of metal shown at A and B. In the projectiles first made, this was effected by wooden discs having pieces of lead let in at one side, the shot being suspended; these were turned until it hung true between two points, which were previously known to be in the same vertical line, they were then secured by a bolt as shown.

As has been stated, this arrangement was far too weak, and gave way when the shot was fired.

It is proposed, therefore, to substitute pieces of metal secured in the manner shown, and which it is believed will stand the force of explosion of any charge without disturbance. From the experience gained, it appears that the cost of correcting the centre of gravity of the largest shot would be very little; not above a few shillings.

It has been objected to the system proposed, that it can pretend to no advantage, not obtainable with shot of simpler construction fired from rifled guns.

In reply to this, the author submits that the proposed shot and shell are simple, there is neither lead-coating nor studs; as to cost, they might be made as cheaply as rifled projectiles, for the expense

* In the case of the smooth-bore, the shot moves in a curve in the vertical plane, whereas in the case of the rifle, the shot has also to move in a lateral curve, making the actual path of flight the resultant of the two, a curve of double curvature, which appears to be not calculable.—M.S.

of correcting the centre of gravity is little, and there is saving in other directions—this point deserves notice. Until a recent date the cost of the heaviest shot employed, such as that for a 68-pounder, was only a few shillings, and the addition to that price of two or three shillings more would be a large percentage; but when we take rifled shot weighing 300 pounds, even of cast-iron, the cost is considerable, and in this case the addition of a few shillings is a small percentage. Further, in the case of steel shot, the cost is enormously enhanced, and the proportion of the few shillings for correcting the centre of gravity, is correspondingly diminished. But more, the cost of the shot is the cost when it is fired, and the large charges of powder now employed involve a corresponding increase in expense, and in the case of shell, the bursting charge would have to be added. Putting these items together, it will be found that the cost of correcting the centre of gravity is a trifle compared with the cost of modern projectiles *fired*, and if the slightest addition to accuracy could thereby be obtained, it appears to the author that it would be well worth the money.

In conclusion, the author would add that, of course, there is no intention, on his part, to speak dogmatically upon a subject so full of difficulty; his desire is to submit these ideas to the Institution, in the hope that they may lead to discussion on the part of those who are more competent to deal with such questions.

Commander COLOMB, R.N.: I should like to ask two questions which have suggested themselves to me. Firstly, I did not quite understand whether the mere correction of the centre of gravity was sufficient to prevent the shot turning over. Secondly, I do not think it was quite clearly made out how the altered shape of the shot would be sufficient to correct the oscillation which the lecturer stated occurred with the hemispherical-headed shot.

Mr. M. SCOTT: In answer to the first question I think I stated that there was more than the correction of the centre of gravity required. I have taken up the subject at the point where it was left in a pamphlet which I published. I did not desire to go over the same ground, for I dare say many gentlemen present are acquainted with it; and it would have been tedious to discuss the same question again. But it was stated that the correction of the centre of gravity and the perfection of the symmetry were both required. I am unfortunately unable to state what effect this modification of the form would have had. I wish to have it tried. The original forms were only two, the hemispherical and the flat. We found that neither of them was satisfactory. I then proposed to modify these forms for the reason given in the paper, and to make them like Figs. 5 and 6. I applied to the Government for an opportunity to try a shot of that form, but that offer was unfortunately refused. Therefore it remains a question whether it would have the desired effect or not. I have stated my reason for thinking that it would be an improvement upon previous forms; but as to whether it would remove the oscillation altogether is quite another question.

Captain TYLER, R.E.: I have always understood from Mr. Whitworth's experiments,—in fact from all experiments that have been made,—that one of the first principles of projectiles was that when you departed from the spherical form and began to elongate the shot, unless you began at the same time to rifle your gun in order to make your shot rotate, the projectile at once began to show symptoms of turning over; and further, that the more elongated the shot was, the more that tendency exhibited itself. I had the pleasure of being in Mr. Whitworth's gallery, and seeing some of his earlier experiments; and I remember at that time that the pieces of paper which he placed at intervals across the gallery showed the points at which the projectiles turned on their sides; and showed very

distinctly that when, as Mr. Whitworth originally proposed, he elongated his shot to an unusual extent, he was at the same time obliged to increase the number of turns in the gun in order to overcome the tendency of the shot to fall on its side instead of going straight forward. Now, if what Mr. Michael Scott has stated is correct, it would appear that he has the idea that he can, by merely balancing his shot, overcome that tendency.

Mr. M. SCOTT: The cases are hardly parallel. Mr. Whitworth's shot were solid; consequently the centre of gravity would be far back. My shot are hollow behind; and these two shot on the table were actually fired and did not turn over. They have a considerable length in proportion to the diameter. But it is not a parallel case quite with shot that are solid throughout.

A MEMBER: Were any practicable means taken to verify that the shot did not turn over?

Mr. M. SCOTT: In this way: First we saw them throughout the flight. But there was a better proof than that: The range sergeant who had the noting of the grazes stated that in this case the graze was a long shallow scoop in the sand; so that even when the shot touched the sand, it did not turn over.

Captain TYLER: I dare say Mr. Whitworth, who has had great experience in these matters, will kindly tell us whether he has observed that anything of this sort can be produced: that it is possible to fire an elongated shot that shall not turn over without at the same time giving it rotation.

Mr. WHITWORTH: I will state that I never fired an elongated shot without giving it rotary motion. I have never tried the experiment; but I know this very well, that if you give a small rotary motion to elongated shot it will turn over, and that the longer the shot is, the more rotation you must give it.

Captain TYLER: That is what I understood from your earlier experiments.

Captain BURGESS: Provided it is solid.

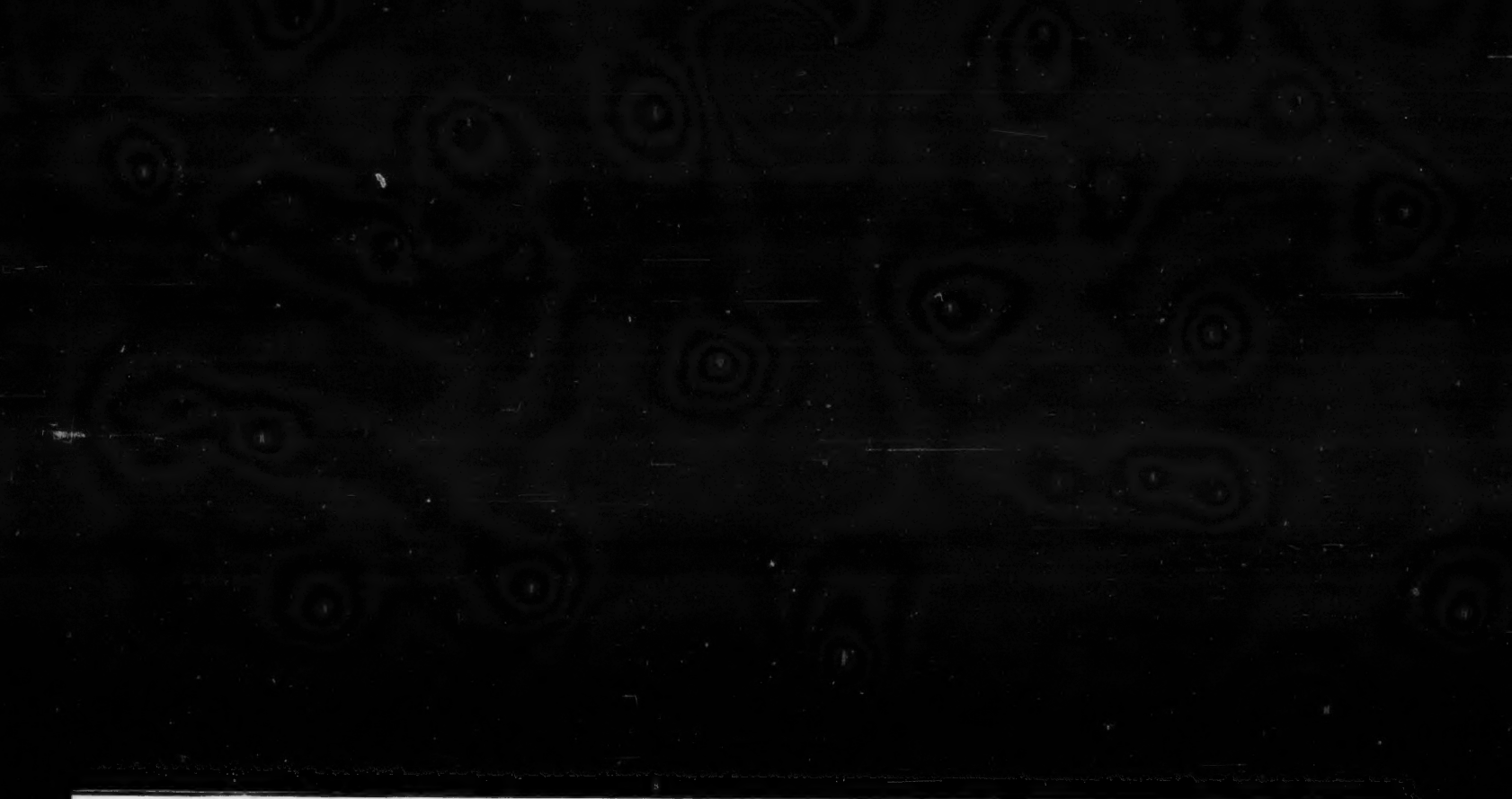
Mr. WHITWORTH: No matter whether it is solid or hollow.

Captain COLOMB: One would suppose that if the rear-end of the shot were much lighter than the fore-part, the tendency to turn over must be proportionately reduced.

Mr. M. SCOTT: That may be true in its degree; but if the centre of gravity is not in the centre of the figure, the condition you suppose would not be sufficient.

The CHAIRMAN: You will doubtless allow me to give your thanks to Mr. Scott for his contribution to the science of projectiles. After what Mr. Whitworth has said, that he has never tried the experiment mentioned, his statement can be no negative to what has been tried. The experiment has been made, and it really appears to me to answer satisfactorily. It is unsatisfactory that such a gun as the one described, which was imperfect, should have been supplied for such a purpose; but it is only what we have had to say before with respect to the guns that were employed for the spherical shot. They were the most rough, we might even say, disgraceful guns. There was no real comparison, no scientific comparison, no skill, no care there. We have pretty much the same thing here. The gun which Mr. Scott has described in the paper was so unequal in the bore that the shot jammed near the trunnions, and it took considerable force to get it home. Apart from any defect in the gun, we must have expected oscillation in the projectile. Therefore it was an experiment all against the projectile. If the gun had been better suited to the purpose, the projectile, as we might reasonably have expected, would have given better results than it did. However, this paper is a contribution to the science of projectiles. It is interesting to know, that that which had been conceived to be impossible, is not, so far as we can rely upon Mr. Scott's information, impossible; that an elongated shot can be projected, and that it will not turn over, if the adjustments are had respect to. It is interesting in this respect too, that with his *balanced* shot a much higher initial velocity is obtained than from the elongated *rifled* shot. Although there was a deficiency in the range, that deficiency seems to have arisen from the greater oscillation. But if you had a perfect gun you might reasonably expect that that oscillation would be materially reduced, and that the range would be materially increased. We have heard admissions lately made at the Institution of Naval Architects with respect to initial velocity; and, by the way,

we should have heard nothing at all about that, if it had not been necessary to support a particular form of construction of vessel. Those who were behind the scenes were let into the secret, and they were told, with regard to a certain experiment, that there was a different description of powder used, and a different initial velocity obtained to that which was reported. But, surely, this is very unsatisfactory. It casts a doubt upon all these experiments. The initial velocity given here, not obtained by Mr. Scott himself, may be incorrect, but it is comparatively correct, and is greater than the initial velocity obtained from the elongated shot; and as it was stated at the Institution of Naval Architects that the difference of initial velocity, though not great, made a difference of an inch of iron in plating, it becomes a very serious and a very important question. It is desirable to get higher initial velocities with safety, particularly when we see the number of guns that give way with large charges. The *Times* to-day mentions Major Palliser's gun. I do not know what initial velocity it gives; but it is quite clear that initial velocity is one of the prime elements for an effective gun. Therefore, anything that will help us to get that without bursting the gun is a *desideratum*. It cannot be but that in rifling the gun, and especially in using studs on the shot, the gun must be materially weakened; therefore, in that proportion with guns so scored, it is impossible to fire large charges. The gun for these shot has no score, therefore it is proportionably stronger. Considering the measure of success Mr. Scott has obtained, it is a waste of money to make experiments in this way. It is very strange, when a man undertakes to pay the expense of these experiments himself, in order to solve problems in science which involve such results as these, that he should not be supplied with a proper gun. However, be that as it may, we have to thank Mr. Scott for his interesting paper.



WAR MAP
OF
IRELAND
BY COLONEL ADAIR F.R.S.
A.D.C. to the Queen
Tory Ht
Bloodyforeland Pt
Arran
Donegal
Donegal B
Ballyshannon
Urris Hd
Killala Bay
Killala
Sligo B
SLIGO
ENNISKILLEN
L. Allen
Ballina
Belleek
Achil Hd
Clare R
Castlebar
Maye
CARRICK ON SHANNON
Shannon R
ROSCOMMON
Sligo Hd
L. Corrib
South R
Athenry
Galway
Galway Bay
BALLINASLOE
Leughrea
Shannon R
BANNAGH
L. Derg
Ennis
NENAGH
Kilrush
Askeaton
LIMERICK
Shannon R
Mouth of the Shannon
Tipperary
CASHEL
Cahir
Tralee
Dingle B
Killcommin
Blackwater R
Fermoy
MALLOW
Macgillicuddy Reeks
Kenmare
Macroom
R Lee
CORK
Youghall
Bandon R
Kinsale
Cork Harbour
Bantry
Bantry B
Glengariff

J. Johnson

NOTE.

Stragetic Points, 1860, First Class	thus	TRIM
Dº Dº 1866 2nd Class	"	NAVAN
Alarm Posts 1866	"	Tralee
Sir John Perrots 7 Towns 1584	"	▣
Dº Dº 7 Castles	"	▲
Dº Dº 7 Bridges	"	⌘
Battle Fields	"	⚔
Cromwells personal Conquests underlined	"	TRIM
Railways completed	"	~~~~
Dº in progress	"	.....

LECTURE.

Friday, April 13th, 1866.

GENERAL SIR JOHN F. BURGOYNE, BART., G.C.B., R.E., in the Chair.

IRELAND, HER WARS AND STRATEGICAL HISTORY.

By Colonel R. A. SHAFTO ADAIR, F.R.S., Aide-de-Camp to the Queen.

THE subject on which I have the honour of addressing you, comprises a portion of the history of one of the most remarkable races of Western Europe. The original inhabitants of the land, whose military history I shall endeavour in brief to set before you, form the extreme right of one of those great portions of the human race, which, resting with their left on the eastern shores of the Mediterranean, swept the Greek colonies, and with their main battle stormed the Capitol of Rome. The prominence of this race in warlike pursuits long showed itself by the Atlantic sea. For the early military history of Ireland commenced previous to that which is recorded in the annals of England. Years before the first Norman horseman had crossed St. George's Channel, savage and terrible wars had raged between the native chiefs and the Danish invaders. The Danes had established settlements throughout that fair land; and in reading the history of these early times, you will constantly be struck with the remarkable development of military and strategical science in the contest between those two great peoples, as given by bard and chronicler.

But my business to-day is with that well-defined history, which emerges from this twilight, and is recorded in authentic annals. In the consideration of the five or six great periods of war into which the military history of Ireland divides itself, it will be remarked that campaigns, as well as battles, were mainly determined by topographical circumstances.

Ireland, topographically is distributed into river systems; and on those river systems to a great extent, depended the origin, formation, and the course of wars. For instance, in the valley of the Barrow and the Slaney, passing northwards to the Liffey and Boyne, it is

easily discovered why the strength of the Norman conquerors was first concentrated within those borders. In tracing the line of the northern lakes from Ballyshannon to Dundalk, it will be perceived wherefore the north constituted a great fortress, from which native war was waged against intruders on the Irish soil. In the line of the Shannon, passing through a long series of lakes, will be seen the district in which the native chiefs and their followers found refuge when they were unable to stand before the organised system of Norman war. And in the valley of the Blackwater, that great district which is comprehended between the Suir, the right bank of the Barrow, and the Nore, you will observe the circumstances that gave facilities to the Normans to entrench themselves in the defensive works which are specially adapted to their arms; in the fortified Norman castle.

I have said that the military history of Ireland commences earlier than that which is recorded in the annals of England. And to any one who has traversed Ireland with the eye of an antiquary, it must have constantly become evident that the native races had the habit of forming earth defences of a regularity and a consistency which have enabled them to remain undestroyed, although degraded in outline, to the present day. And wherever the mound which is is now called the Danish *rath* or *moat*, but which I prefer to believe the residence of the early Irish chieftain and his followers, is found on a river a ford almost always is near. The bridges of Ireland are determined by the ford, and the fords are marked by the *raths* or the *moats* of that country.

The early history of Ireland not having commenced with the inroads of the Normans, it is not particularly necessary to dwell here upon that section of her history. Nor, indeed, till the close of the reign of Henry VIII, is there very much from which a soldier can gather instruction, except in power of endurance and display of gallantry in the field. True it is, that some of the great battles that have left an impression upon the popular mind even to this day, were fought in the twelfth, thirteenth, and fourteenth centuries. The fights of Knocktuadh, or the Hill of Axes, in Galway, 1189; Credran in Sligo, 1257; and Ardnocher, near Mullingar, 1328, have a place in Irish legend and story. There was the war of invasion of Edward Bruce, which was waged principally in the north, and successfully. But till the close of the reign of Henry VIII, there is very little on which I need observe.

With the termination of that monarch's life, and the enthronement of his successor, a novel phase of war was developed in Ireland. Europe, at that time, was disturbed in its length and breadth by a conflict, which did not fail to convey its pulsations even to the remote island of the Western sea. The wars of Elizabeth which had been waged in the Netherlands against the preponderating weight of the Spanish monarchy, were destined to be continued and fought out on Irish ground. And there was another cause that lent an intensity to this warfare, resulting from the personal relations which the King of Spain and the Sovereign of England bore to each other.

The early wars against the Plantagenet kings were simply those which

the Anglo-Irish, who had retired beyond the pale, waged against their suzerain, or were at the worst, of feudal dependents. But in the wars of Elizabeth, national feelings were enlisted, and national enmities aroused. At that time also, the native Irish chieftains, having amalgamated their power with the Anglo-Irish descendants of the Normans, were competent to take that share in scientific military struggles, for which their previous modes of warfare had not fitted them.

Again, it is to be remarked, that the system of the campaigns in which Elizabeth's generals engaged, was determined very much by the character of the country. When it became the policy of the Lord Deputy to carry his troops to the northward, it was almost always by continuous expeditions and by displays of strategic talent, some of which were well conceived for the end. When, on the other hand, the strife was with the rebels of Munster, a country studded with the castles of the Anglo-Norman chiefs, it was then a war either of raids and rapid expeditions, to deprive the enemy of the cattle from which they derived a large proportion of their commissariat; or, of single enterprises in which castles were taken by storm, and, in the Irish phrase, "defaced;" very much as two centuries before is recorded in Froissart in the wars of Guienne and Normandy.

But at first, it does not seem as if the Anglo-Norman-Irish and their Irish allies cared particularly to seek for foreign help; for it is not till the year 1567 that the Confederated Irish betake themselves for succour to the Spanish King. One of the greatest of Elizabeth's soldiers was Sir John Perrot, a man of exceeding talent in council, and of great resolution in the field. He, with far-seeing sagacity, proposed not only a system of bridling the revolted chieftains by castles, bridges, and towns; but also of deriving a revenue from the country which should defray the cost of the operations of the troops. One of his proposals was to build seven towns, Athlone, Dingle, Coleraine, Liffer, Sligo, Newry, and Mayo. All these points are selected with great attention to strategical value. To fortify the passes of the country with seven castles; on the Blackwater of the north, at Ballyshannon, at Belleek, to the eastward of Ballyshannon, at Castle Martin; in the Queen's County, at Sallins; at Kilcomane, in the south country, and at Broadwater in Munster. He proposed also, for the communications, to build seven bridges: at Coleraine, at Liffer, at Ballyshannon, Dundalk, Fermoy, in the south, at Veale on the Slievelogher, at Kell in Clandeboy, and at Dundalk. It seemed, therefore, as if Irish warfare was becoming more difficult to the Crown of England than it had hitherto been. Certain it is that, with the accidents of a strong country, the mode of equipment, and the commissariat, which was not so highly organised as at the present day, very considerable difficulty might have existed.

For instance, it is well said, that "from the north all wars come." And in reviewing this frontier to which I have already directed your attention, from Ballyshannon to Lough Erne, along the system of northern lakes, and thence to the hills of Armagh, Monaghan, and Lowth, till the sea at Dundalk is reached, but three or four passes exist through which troops can advance into that country. Along a

great portion of this frontier, it would be difficult now to pass guns and cavalry where, nevertheless, guns and cavalry were passed when the country was incomparably less suited for a warfare which requires heavy armaments and scientific arrangements. To the eastward there were but two passes; from Dundalk round to Newry, and the Moyry pass in the hills of Armagh and Louth. If any of my hearers have gone by railway from Dublin to Belfast, they may possibly remember that shortly after ascending from the plain country at Dundalk, a wild district of mossy and rocky table land is penetrated before the hills at a considerable elevation above Newry are passed. There is a pass through which the railway now takes them in some four or five minutes, which detained Lord Mountjoy, with the best of the Queen's troops for many days during these wars. The advantage to O'Neill, or the rebel generals of the north, was, that if beaten on the Moyry pass, or the alternative passes leading from Dundalk through Kilkeel and Carlingford to Newry, they then retired on the northern Blackwater, which affords but two points of crossing; at Charlemont, where a ford was built by Mountjoy, and at the ford of Benburb. The alternative was for the English generals either to be checked at the passes of these hills, or compelled to accept battle, which was certain to be offered at Benburb. If the northern troops were defeated, there was open to them a safe retreat through the whole of the wooded country to the left of Lough Neagh; and finally, after the fashion of clan warfare, the dispersion of the tribes left no opportunity, thoroughly, to break their strength.

But the generals of Elizabeth were not without their counsel also. Finding the difficulty that arose from this description of warfare, they reversed, as it were, the front of the northern rebels by constructing one fort at Derry and another at Ballyshannon. The consequence, as will be perceived at once, was this: that, after forcing the passes of the Dundalk system, the English troops, in their advance, were approaching their commissariat instead of retreating from it; and since the command of the sea was always with the English navy, the transport of reinforcements was easy.

Frankly, nothing is more difficult than to select, among numbers of gallant deeds and remarkable achievements, some few as types, signs, and specimens of the warfare of those times. And first, of a most remarkable march made, in 1594, by Sir William Russell, Lord Deputy.

Enniskillen was besieged. The Lord Deputy resolves to raise the siege, and passing, on August 19th, from Dublin to Trim, from Trim to Mullingar, Athlone, Roscommon, Abbey Boyle, on the 26th passes the Curlea mountains, thence by Drumlane, over the hills of Killarga and the bogs of Ballynamarla, passes the Erne River on the 30th with 500 men, relieves Enniskillen without stroke of sword, and returns to Dublin on the 9th of September. Then, with regard to Derry,—that Derry was not the Londonderry of the famous siege. It was a small post occupied by the Queen's troops. On one occasion it was necessary to abandon it before the inroad of the northern rebels. The garrison, being principally of infantry, were embarked, but there

was a troop of horse commanded by one Captain George Harvey, who resolved they would not leave their horses, but that they, with their horses, should pass through the enemy's country unharmed. This gallant man took no counsel but of his own courage, and marching through a country swarming with enemies, broken and difficult as it then was, he presented himself, at length, at Dublin with his command undiminished by fatigue of way through Tyrconnell and Connaught, or by perils of war. Such deeds should never be forgotten; for when the toil and peril are realised with which such gallant resolutions are carried into effect, it will be seen how well such men deserve of their country, and a place in English history.

Another peculiarity of the military system of Ireland was the position which the citizens of Dublin occupied in the warfare of the times. The number of expeditions in which they are named, from 1466 to 1598, in 132 years, is fifteen, in which they deliberately took the field in support of the Royal power, or on their own behalf. On one occasion the Royal troops not being available for the relief of Dundalk, the town was relieved by the armed citizens of Dublin.

But not always was victory to the Queen's troops. No; on some occasions there were sad and terrible defeats. The Irish fought well; and they fought with a determination which won for them the respect of their opponents; and no man who has read the account of the famous "Pluck of Plumes," in which the chivalry of Essex were defeated by a body of Irish, but will say that those men were the true ancestors of the gallant Irishmen who have carried the British arms throughout the world.

But the warfare that had been waged against discontented families of the old Anglo-Norman type or the native Chieftains of the North by the Generals of Elizabeth was about to be finally closed in the most distinct and decisive manner on the southern shores of Ireland. Two inconsiderable expeditions, comprising a small number of Spaniards, had been landed at Smerwick, on the west, whence, on one occasion, they had penetrated into the country, and had been taken prisoners. On another, they constructed a small fort, which was besieged by the Lord Deputy Grey de Wilton, called the Fort Dell'Oro. There one of those terrible tragedies was enacted on which the historian hesitates, the soldier reads, and is silent. The garrison was put to the sword, and for a time there was no further inroad by the Spaniards. But Spain had not forgotten her soldiers. At Kinsale, in 1601, the Spaniards disembarked a large body of forces. An impression had for some time existed that a Spanish invasion was imminent; yet there was but one man, and fortunately he was the man in the right position, who had guarded himself, for the struggle he saw was inevitable. The Lord President of Munster, Sir George Carew, chief of the artillery of England, had for six months previous been providing for the storm, and when it came, he was prepared for it, in that quiet, unobtrusive way in which true soldiers await a difficulty. At the Council table he told the Lord Deputy and the astonished Council that he had already accumulated six months' biscuit by paying his men in money instead of issuing their rations. The Lord Deputy arose and embraced him,

and forthwith placed the confidence in him which the soldier deserves who, with simple expedients, stores up the elements of success. Kinsale was besieged. The Castles of Berehaven and Castlehaven were occupied and formed into works dependent on Kinsale under the Spanish military system. The siege proceeded with varied success; but at length news came to the Lord Deputy that the northern armies with Tyrone were on the march, and that while he maintained the siege he would have to fight a battle in the field. He was equal to the emergency. With one hand he drove back sallies of the garrison of Kinsale; with the other he smote Tyrone to defeat within six miles of the fortress. Hence a collapse of the Spanish efforts to make and maintain their footing in Ireland. The treaty of Kinsale closed a great war; Tyrone's submission followed; and for forty years, with but trifling exceptions, the land had peace.

In the reign of Edward VI. the O'Mores and the O'Connors lost territories which are now called King's County and Queen's County. There was a partial insurrection under Sir Cahir O'Dogherty at Derry, but effectively there was no warfare to disturb the Imperial repose. But the storm was brewing. In 1641 one general burst of insurrection enveloped the English garrisons and cities in its fury. The Irish of the North, under Sir Phelim O'Neill, swept through the country, so that before Christmas the English held only Londonderry, Carrickfergus, and Drogheda, in the north; Cork, Youghal, and Kinsale, in the south. Dublin remained the city of the Lord Deputy under the English administration, but beyond the walls of those cities there was no place for a family of English blood. Lord Ormond, in his duty to his sovereign, marched out of Dublin; and the Scottish forces, collected in the north-east, defeated Sir Phelim O'Neill at Newry.

And here I must pause for a moment to remark on a new warlike element that is introduced into Irish history. It was in the thirteenth century that the first inroads were made in the north-eastern angle of Ireland by the isles-men of Macdonnel on the district which is called the "Route" of Antrim. They seized the lands of the sept of the M'Quillans at Dunluce, and thence gradually spread over the country. In the interval between the death of Elizabeth and the outburst of the northern insurrection, the Scottish settlers had become very numerous, and had introduced themselves as a foreign and intrusive element. Consequently their interests were distinct from those of the native race. Although they probably might not, in accordance with the Scottish policy, be well affected to the English Crown, they were nevertheless a population hostile to the Irish.

While Sir Phelim O'Neill was battling with the Scottish settlers, another and an independent body arose in the south-west. These were the Roman Catholic confederates of Kilkenny, who formed what was called the army of Leinster. They declared for the King; but, nevertheless, were not disposed to submit to the military government of Lord Ormond. In fact, the northern army under Sir Phelim O'Neill, called the army of Ulster, and the southern army under General Preston, called the army of Leinster, or the Catholic confederated army, combined to hold their ground, first of all, against the Scots, and

then to maintain an armed neutrality against Lord Ormond and the army of the King.

But the influence of the Parliamentary party in England was now beginning to make its way in Ireland. The same cause which brought Ormond into the field brought the confederated Catholics and the army of the north—the army of Ulster—into the field against the Parliamentarians and the Scots, who were equally obnoxious to both. But though the resistance directed against what was evidently the parliamentary policy of England was overcome, there was no opportunity afforded to the Parliament for seven years of sending any troops to Ireland to renew that defeated policy. It is a complicated task, and of most conflicting evidence, to trace the different operations of these four distinct armies. The army of Ormond, the army of the Confederates, the army of the North, or Ulster, and the Scottish army, each had its own separate interests. At one period, towards the close of 1647, Lord Ormond appears to have been endeavouring to make terms with the Catholic army and the Scottish at the same time; and thus the war might have lingered on year after year with but very little change, had not the popular power in England, shaking off its native opponents in the Royalists of England and Scotland, found time to turn attention to the Irish wars. The first sign that was given of the altered state in which these wars would be waged was by the appearance of that great soldier, Cromwell, in Dublin. It had been his intention, originally, to land in Munster; but his Lieutenant-General, Colonel Jones, having, by most successful strategy defeated Lord Ormond and the Royalists proper, to the northward of Dublin, and in the neighbourhood of Dublin, Cromwell turned thither, and thence began his mighty career. In seven of the noblest and clearest despatches in the English language he shows how, in nine months, he swept through the country as never conqueror swept before. From Drogheda to Wexford, Ferns, Gorey, Youghal, Waterford, Dungannon, through the whole westward of Munster, by New Ross and so to Clonmel. To shorten the history of his great battles, that chief met with neither check nor defeat, and, from a strategical point of view, it is instructive to mark how he passed on, securing his positions as he advances, leaving unnoticed or masking what can be left, storming what must be stormed, connecting links of communication; always victorious, always successful, always just, and always careful for the soldiers who enabled him to perform such great deeds. There is a rock near Maryborough famous in Irish story, whence the line of the South Western Pale can be seen. The greatest castle of the Fitzgeralds can thence be seen —you can mark the circumstances of the ground by which the Western "Pale" was naturally bounded; and, standing there, I have marvelled how the artillery of those days was transported that breached the fortress which crowned this rock; how the guns were got across the surrounding moss; but wherever he laid his hands the work was thoroughly done, and it was done as described in despatches, which reproduce vividly every detail of action, and described in a spirit which, to my mind, proves the soldier and the statesman. In 1649 Cromwell quitted Ireland, but it was not till 1652 that the adoption of

the articles of Kilkenny enabled the Parliament to withdraw their forces from the field. Permission was then given to those who had served against the Parliament of England to transfer their arms to any country with which the Parliament was in amity. 7,000 troops were embarked then for the service of the King of Spain, and 3,000 more in the following year. 5,000 more took service with the King of Poland, 3,500 went to serve the Prince of Condé in France; and between 1651 and 1654, 34,000, of whom few ever saw their loved native land again, were passed beyond sea as soldiers into foreign lands.

Such was the first great exodus of the military strength of Ireland. Such was the first occasion on which the soldiers who should have found an outlet for their valour, and fields for their gallant actions in the service of the British Crown went, alas! beyond the seas, as has been said,—

> "To turn the scale on foreign fields
> For foreign monarchs' gain."

It was not the last, as we shall see, when we come to the record of the wars of Britain.

It was to be supposed, as history has shown, that in the course of time the seed that had been sown during the wars of the Commonwealth, both in politics and arms, would bear fruit. So it was in England, and so eventually in Ireland, when the King had left Whitehall at the approach of William. It was not probable that he ever thought to wage successful war for his crown in Ireland; for at that time, owing to the diminution of the military caste in Ireland, the genius of the nation was not held very capable of military adventure. Moreover, the Ulster plantation overlaid with a stern and resolute population all that existed of discontent in the divided portion of the south and west of Ireland. But it was soon perceived that there was a lever by which, perhaps, the State might be so moved that the Crown might be regained for the fugitive monarch; and the French King who now strained every effort in war with England, gave the exiled King, liberally and royally, assistance of treasure, arms, and men.

It is remarkable that here also the two chiefest exponents and champions of opposed systems of policy were again brought face to face, and for a conclusive struggle on Irish soil. What Philip the Second was to Elizabeth, the French King was to William the Third—an equal destiny and the same fate awaited both. It was perceived that Ireland must be the field of battle, and a fresh insurrection gave the first signal of strife. Kenmare, Enniskillen, and Londonderry were respectively the scenes of a stout and soldier-like resistance, which gave time to their countrymen to collect their strength in aid, and to England to marshal her powers for their deliverance. Of these two famous sieges but little need be said. All men know with what constancy the defence was maintained, and how from that double base of operations, Enniskillen and Londonderry, the subsequent campaigns may be said to have proceeded. Yet to Kenmare isolated, and of weak

resource, no less honour is due. William was, above all things, a soldier, and the Generals trained under his charge and care were soldiers of the first capacity. Schomberg arrives in Carrickfergus, and disembarks there with little or no resistance, but perceives that his troops are insufficiently drilled. He retires to winter quarters at Lisburn, occupies Dundalk, and awaits the spring. With the spring came 30,000 soldiers from England, and with them a man whose strategical merits and personal character were not to be weighed by any amount of mere military experience. William the Third finding the troops properly drilled, advanced to the southward, till no barrier but the Boyne lay between the armies, and a battle must evidently be near at hand.

It is noticeable how in war striking incidents repeat themselves. It will be remembered that Moreau lost his life under the concentrated fire of field guns across the Elbe. The same artifice, I will call it, had been practised against William, at the battle of the Boyne. It is interesting to read the account, as well depicted by our latest historian, of William, while at breakfast, looking at the allied Irish and British troops, being greeted by a salvo of artillery, which strikes his shoulder sufficiently to draw blood, but not to disable. William's army was composed, in accordance with the parallel I have instituted, of those whom a thirst for freedom of conscience had driven from their home—the French Huguenots; and of those from England who were prepared to maintain the free rule of William's Government. The field of battle is easily comprehended, since it is comprised almost within the two banks of the river Boyne. On the right of William's position is the bridge of Slane, in the centre lies a ford which can be passed by infantry; and on the left the cavalry were to advance. The bridge of Slane had been singularly neglected by both generals, and as each perceived his error, he endeavoured to seize the important position. The bridge of Slane was occupied by a detachment of William's cavalry, who thus turned the left flank of James's forces, and when the Huguenot battalions and English infantry advanced through the stream to the attack of the old ford, they fell on an enemy already shaken by a cavalry advance on their left. So the battle of the Boyne was won. The army of James retreated to Limerick; and the result was that Ireland was divided between the two Kings, pending the final struggle. William's garrisons lay from Castlehaven to Mallow, from Mallow to Cashel, from Cashel to the northward to Longford, from Longford to Cavan, Cavan to Enniskillen, thence resting on the western sea. A proportion of neutral territory lay between, but King James's troops had the entire control of the province of Connaught, of both banks of the Shannon, and of a very large portion of Munster.

The first expedition that was made, was to form the siege of Limerick by William, whereat a gallant feat of arms was done by a noble soldier of King James. William was bringing up his artillery for the siege. It had reached a point some miles on his right rear. Sarsfield detaches himself from Limerick, makes a detour to his right, surprises the park and convoy, and the first thing that is known of the destruction of the expected park was from the explosion of the bursting guns. Sarsfield

effected his retreat in safety, and Limerick was for the time saved. Yet though it was scarcely to be conceived that the Great Deliverer would leave his work half accomplished, yet from October, 1690, till May, 1691, nothing was attempted in the field, while preparations were made to close the campaign. Meanwhile Marlborough (his first appearance in our civil wars) had taken Cork and Kinsale. The garrison of Cork had been allowed to retreat to Limerick; the garrison of Kinsale were retained as prisoners.

The army of William broke up from winter quarters and marched to Athlone. Athlone was always held to be the chief military position of Ireland. On the Shannon, flanked by morasses, lakes, and currents of that stream, it could only be attacked in front, and thus is of a naturally strong character. At this time the French general, Saint Ruth, had been sent to take charge of the Irish officers. He superseded, to the great regret and discontent of the Irish, their General Sarsfield, a noble soldier, as has been shown.

The siege of Athlone began. Situated on the Shannon, and divided into the Irish and English quarters respectively on the right and left banks, the fall of one portion by no means inferred the fall of the unassailed portion. The English quarter was soon breached and carried. Saint Ruth broke down the bridges that connected the Irish quarter—that is to say, on the right bank—with the English quarter. He had previously committed a great fault by allowing his garrison of Ballymore, which is in advance of Athlone, to be surprised. There he lost a thousand men, which dispirited his soldiers; but with that exception he appears to have fought cautiously and well. But then arose this difficulty. He left Athlone to be defended by his Lieutenant-General D'Husson, and himself retired some distance to the left rear, under the impression that his presence was not required; and thus the fortunes of Athlone hung upon a thread. It is said in a remarkable work on the defence of Ireland, published in 1795, that a council of war seldom fights; but on this occasion the council of war summoned by De Ginkle determined to fight. And they fought on this wise: they saw it was impossible, without a wasteful expenditure of men and a great loss of time, to carry by siege the remaining quarter of Athlone. They therefore determined to storm, without breaching, at a ford some short distance above the broken bridge. I believe there is no instance in history of so large a storming party assaulting so strong a place as the forlorn hope of 1,500 grenadiers, who crossed the ford of Athlone, and in ten minutes made the Irish quarter their own.

Saint Ruth found his mistake when too late. He was, however, of promptitude equal to any emergency. The next morning it was perceived that his troops were directed in retreat to the country between the Shannon and the Suck, on a point at Aughrim. This is a famous name; famous for a battle fought in a scientific and admirable manner. Saint Ruth retired to a position at which he had on his front a long low line of bog, on his left the old ruined castle of Aughrim, and was posted so that there was no point on which it would appear that troops could approach him except on his right flank. But he omitted to project on his right front a force sufficient to occupy that pass through

which the English infantry were enabled to advance to the attack. He then brought up cavalry from his left for the purpose of outflanking the British infantry in their turn on their advance. That left an opening to the northward of the bog on his left front, across which the English cavalry struggled, turned his left flank, and enabled the English infantry, which were then moving through the bog up to their waists, to storm his intrenchments and secure the day. Saint Ruth's head was carried off by a cannon shot. He had not given any instructions to Sarsfield, his second in command. There was no one to give any orders, and no one to receive them. The broken army of Athlone fled in disorder; and the only places then capable of opposing the English were Limerick and Galway. Galway after a time surrendered. The investment of Limerick was immediately formed.

It may, perhaps, surprise many to hear that pontoons were used at the siege of Limerick for passing cavalry over the river. Limerick stands as Athlone, divided by the Shannon. On the right bank the cavalry of James were encamped. Ginkell throws across the stream a bridge of "tin boats," on which he passed over his cavalry, routs and drives into the interior all the cavalry of King James, recrosses with success, returns and destroys the forts on the west bank, and finally drives Limerick into capitulation. A capitulation is made by which permission is given to the defeated troops to leave the country and to enter the service of the King of France. Eleven thousand men elect to follow their Irish leaders and serve under the French King, two thousand to return to their homes, and one thousand to serve under William.

But the contest which had thus been waged to a conclusion between two opposite principles of Government on the Irish soil, did not terminate on these fields. For we find in the inroads into Piedmont by Marshal Catinat, that, while the Irish battalions fought with courage round the standard of the French King, their old opponents, the French Huguenots, again met them under the banner of Savoy, and the fight was maintained with honour to both.

Nothing more remains to be said of the great wars of Ireland. There was a period, however, in which the Irish military character was developed with a rapidity and efficiency which must strike all who have ever read the records. I allude to the enrolment of the Volunteers, when the French and Spanish fleets combined, were riding in the channel. The English Government had told Ireland that no troops were to be spared for her defence. The Irish armed themselves. The history and traditions of that great army show how admirably it was appointed and equipped. The Volunteers would have given satisfactory proof, if any enemy had approached, of what the Irish spirit was, in those times, after an interval of eighty years of peace unbroken, except by the surprise of Carrickfergus.

There is one war that still remains to be remarked upon: It was the last of the wars of Ireland; I speak of the expeditions that were directed from France by the Republican Government against that country in 1796 and 1798.

The expedition of 1796 was prepared with very great care; and

was of very considerable weight compared with other expeditions of those days. It was composed of seventeen sail of the line, thirteen frigates, two frigates en flûte, five corvettes, 15,000 troops, 41,000 stand of arms, twenty field and nine siege guns. It left Brest on the 1st of December, and returned to Brest with but seven ships of the squadron on the 30th. No impression was made upon the Irish soil; and that magnificent expedition was dispersed by the force of the elements, without a single shot being fired by the British forts or troops.

In 1798, the attempt was repeated. Humbert had been stationed at Rochelle with 1,000 men; Hardy at Brest with 3,000; and Kilmain with a reserve of 9,000. Humbert sails from Rochelle, and disembarks at Killala Bay on the north-west. When I come to speak of the defences of Ireland, I shall remark the special conditions which probably induced him to land there. But having remained at Killala a week, he advances into the interior; is successful at Castlebar; but his career is checked, before his final defeat at Ballinamuck. And I now read, with great gratification, an historical record from which it may be shown that Ireland can trust in last resources to her own soldiers for her defence. It is an extract from a work by Colonel Blacker:—

"What service militia regiments may render, is strikingly shown in "the history of the capture of the French colours in Humbert's "expedition in 1798, by the Light Company of the Armagh regiment. "'Humbert, after a sojourn of about three weeks in Castlebar, "'marched northward. He had reason, and (as it turned out) good "'reason to expect he should be joined by powerful reinforcements "'on the shores of Donegal; he had, moreover, some desire of "'plundering Sligo by the way, but being met and turned by Colonel "'Vereker and the city of Limerick regiments at Colooney, he "'wheeled to his right, crossed the Shannon, and made for the county "'of Longford, where he had reason to expect he would be joined by "'a large body of insurgents. He was met near the hamlet of "'Ballynamuck by the advanced guard of General Lake's army. On "'the 8th of September a part of the French, under General Sarrasin, "'at first surrendered, but afterwards resumed the offensive; but "'the main body with their characteristic bravery showed fight, and "'General Craddock (afterwards Lord Howden) was wounded. This "'led to the advance of the Light Brigade and Armagh regiment. "'The brigade consisted of the light companies of the Monaghan, "'Tipperary, Kerry, Dublin City, and Armagh. It moved left in front, "'which caused the Armagh to lead and come first into contact with "'the French—the Armagh regiment moving parallel to it at a little "'distance. The French gave way before the rush of the Light "'Company (under Captain Obre) throwing down their arms, and in "'the *mêlée*, the colours, now at Gosford Castle, fell into the hands of "'a private named Toole, regimental servant to Lieutenant W. "'Dobbs."

Those colours I have seen, and those colours I believe to have been the first wrested by British soldiers from the troops of the French Republic.

Then, simultaneous with this was the unhappy rising which we call the Rebellion of 1798. Twenty-two combats, skirmishes, and battles distinguished that term. On that point it is not necessary to speak.

Now, with regard to the question as to the future Defences of Ireland, or as to systems that have been adopted. In the cleverly executed pamphlet on the Defences of Ireland, to which reference has been made, the author is of opinion that the advance will probably be made from Galway on Dublin. My impression is, that that is by no means the vulnerable point of Ireland. For two reasons. In the first place, the Shannon, defensible in a higher degree than most rivers of equal breadth, is interposed between Galway and Dublin. In the second, an enemy debouching from Connaught, arrives at a plain country on which regular troops and the regular army would be certainly concentrated, in order to have the advantage of acting from a centre to a circumference in whatever direction the danger might approach. It appears then, especially with the means that are now given for transporting troops and ensuring accuracy of disembarcation by steam, that the south-western is the more vulnerable point. It has been matter of public record that the south-western district, the Bay of Bantry, Kenmare, the Bay of Dingle, have occupied the attention of successive governments. In 1807, Sir Arthur Wellesley declared his opinion that Bantry should be made a great naval station. It was fortunate, though surprising, that in 1796 the French Admiral should lay so long in Bantry Bay without having endeavoured to disembark his troops, since in the channels of Berehaven they were sheltered from any wind, and especially from the east wind, which was blowing with fierceness at the time of his occupation. He was not of course aware of that fact, but it is well known that at Berehaven the anchorage is excellent, and also unprotected. Supposing an advance were intended on the capital, rapidity as well as facility of disembarcation are necessary, especially if with the facility, can be combined a power of concentration. The bays of Bantry, Kenmare, and Dingle, afford that facility of disembarcation and of concentration at a point at some distance in the interior which is required for such operations.

It is probable then that the vulnerable point of Ireland is on these western harbours. And although it may be objected, that it is exposed to the rollers from the south-west, still we know that with the power steam gives, that contingency has now ceased to be a formidable danger. Expedition and concentration are the two points that are required at present. But, assuming an invasion from the maritime base of the south-western coasts, still the system of rivers, which affected so powerfully the warfare of Ireland in former times, will equally indicate the place of a defensive campaign now. There is, as I venture to suggest for the criticism of those who will honour me by considering my suggestions, a perfectly tenable and admirable line of defence stretching from Enniskillen down to Cork.

In the first place, there is Galway as a substantial point of defence projected in advance of this line and Galway alone. The line of defence would be traced from Cork, through Mallow to Limerick, thence to Banagher, northward to Athlone, and by Lough Ree

to Enniskillen. In rear of this line may be formed many points of support, from which troops and supplies might be directed on any portion threatened. And supposing this line even is passed in the rear, still the famous old line which defended the Pale, from Waterford up to Mullingar would still threaten the advancing enemy. With regard to the north-west, where Humbert found his hopes deceived, that is not very likely to be again invaded. The shores are difficult and the country is wild, although the population is insufficiently dense to be prepared to resist, so far as a population can resist, a military inroad of an unencumbered enemy. Besides, on their left advance would be the lines of lakes of Enniskillen and the old frontier of the north, which was always so difficult to force.

It may be assumed then that the line to be observed may be most fitly traced between the mouth of the Shannon and the old Head of Kinsale. That preparation should be made for eventualities appears to be evident, for I am not one of those who derive from modern history any sound assurance that nations have unlearned war. It seems that in the public policy of Europe there are elements of strife which may break out, dependent on any accident; and worst of all, elements of strife that may be let loose, not in consequence of a perseverance in a settled national policy, or even of dynastic ambition; but dependent on the personal influence of one or more individuals, on whose frail lives now rests the chance of peace, that we have done so much and suffered so much to secure, and which we must do much more to secure in order that we may not suffer again.

I could have wished, indeed, that a wider opportunity of developing the many noticeable incidents of these Irish wars had been given. There has been in each century a school for soldiers as regards early military science; as regards the later let no man suppose that the instruction, which is limited to a small surface, is therefore incomplete. Tactics can be practised, it may be said, almost in a barrack-yard. Certain it is that the celebrated battles and celebrated manœuvres which all soldiers study, have not required very large fields for their execution.

There is a map which is intimately connected with the defence of Ireland, to which I will direct your attention. It gives the whole of the bog system of Ireland. Those brown marks show all the country that is rendered incapable of cultivation at present by bogs, and which very materially disturb any tactical operations. This must be recollected also, that reclaimed bog is not hard ground. It is possible to cultivate and give the effect of cultivated ground to bog. But although it is of sufficient consistency to support the roots of cereal grasses, or vegetables, below is that want of density that would, particularly with the artillery of the present day, very soon take the wheels of your guns up to the axle. Finally, Ireland is pervaded by a river system, which enables her generals to determine what shall be her line of defence. Ireland has a sea-coast which has vulnerable points, which enables her generals to determine what the points of attack must be in such or such a case. Ireland has a staff acquainted with every incident of country. Ireland, as I have shown you, independent of the

troops of the Crown, has soldiers of her own, who in the very heat of a fierce rebellion did their duty against a foreign enemy, and would do their duty as well again under similar circumstances.

The CHAIRMAN: I am sure we all feel it to be very gratifying to have a gentleman of the ability of Colonel Adair devote his time and attention to the objects of this Institution; and I think I express your wishes in conveying to him a vote of thanks for the very clever dissertation on the many circumstances and events connected with the military history of Ireland.

APPENDIX.

Works of Reference.

Pacata Hibernia, 1633. A history of the Wars in Ireland, during the reign of Queen Elizabeth.

Desiderata Curiosa Hibernica, 1772. Compiled from original papers.

Hibernia Anglicana, 1689–90. The history of Ireland from the conquest thereof by the English to this present time, with a discourse touching the ancient state of that kingdom, by Richard Cox, Esq., Recorder of Kingsale.

Defence of Ireland, 1795.

History of England, by Lord Macaulay. Cromwell's Letters and Speeches, Carlyle.

Cromwellian Settlement of Ireland; John P. Prendergast, 1865. (A work of great value and interest.)

Berehaven Harbour, a Naval Station and Fortifications, on the South-West Coast of Ireland, 1866. Lord Charles P. Clinton.

Evening Meeting.

Monday, April 16th, 1866.

REAR-ADMIRAL R. COLLINSON, C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 9th and 16th April, 1866.

ANNUAL.

Layard, R. V., Lieut., 3rd West India Regt. 1*l.*

Ackland, F. G. D., Ensign Rifle Brigade.

Darroch, D. J. A., Major, unatt. 1*l.*

COLLISIONS AT SEA, AND THEIR REMEDY BY MEANS OF AN IMPROVED SYSTEM OF LIGHTS.

By Commander J. A. HEATHCOTE, late H.M. Indian Navy.

THE subject which, by the kind permission of the Council of this Institution, I am allowed to present to your notice this evening, is that of Collisions at Sea, and an improved arrangement of lights with a view to their prevention. It is scarcely necessary to remark that the disastrous collisions which are constantly occurring are not only eminently injurious to commercial and shipping interests, but are also the cause, oftentimes, of dreadful destruction of human life, with its attendant miseries, and in this view of the subject, as well as that of the destruction of property, I feel sure that any attempt to prevent or lessen such disasters would meet with a kind and considerate reception from an Institution such as this, composed of distinguished officers and gentlemen, and under the direct approval and support of the Government itself. This subject should, no doubt, properly be divided into three heads, viz., collisions between steam-vessels, between steam-vessels with sailing-vessels, and between sailing vessels. I propose to-night to treat only of steam-vessels.

Of the collisions which actually take place, but very few are ever brought to the notice of the public. Where life is lost, the case will most likely be mentioned in the papers, or where a ship is run down and sunk on the spot, it will not pass without mention; but still no great prominence is given even to cases like these, while those of minor importance are left wholly unrecorded. Even the law courts hear only of those cases when there is a disputed responsibility, but many a long bill for damages by collision is paid without their intervention; and it is only those who have to pay the bills that are most sure to hear of

every case that occurs. It is only the underwriters of this country, at Lloyd's, and the various large Insurance Companies at the principal seats of commerce, who can tell how frequent is the occurrence of this particular casualty of the sea, and how disastrous is its effect upon the commercial interests of the kingdom.

But how do collisions occur? What is their principal cause? For some few years of late I have been employed, together with several officers of the Royal Navy and of my own service, by an Association at Lloyd's, whose particular province it is to take cognizance of collisions, and, in fact, of every other disaster of the sea; and while so employed I have certainly heard more of collisions than could possibly be gathered in a much longer period of ordinary nautical experience. My attention has thus been directed to the subject, and particularly with a view to discover the origin, the prime cause of these frequent accidents. I will attempt, therefore, to answer the question. Collisions are not very varied in their attendant circumstances, their main features are all very similar. I do not mean to say that there are not differences, which to the minds of the astute lawyers who have the handling of these cases when they get into the Courts of Admiralty, are constantly discovered in the interests of justice, differences of essential importance in adjusting responsibility, but on points which inferior minds might, until enlightened, think altogether of minor consideration. Such differences as these there are, no doubt, but still it will not be denied that collisions invariably involve a mistake, a misapprehension on one side or the other, this is followed by alarm and confusion during which the contact occurs, with more or less damage. This, at least, is what is to be inferred from any evidence that may be taken, or any explanation that may be given of the occurrence; for the evidence is always conflicting, the explanations are seldom satisfactory. But of what nature is the mistake, the misapprehension, which is the foundation of the whole matter? Are there not rules of the road at sea as well as on land, with the advantage of those, for the sea being all alike for nearly every civilised nation of the globe, so that a vessel meeting another on the seas at night may feel sure that there is a compact between them as to what each shall do in order to pass on in safety? Such is, indeed, the case, and yet A meets B at night, and the first thought which occurs to him is, "Which way is B going?" and B sees A, and wants to know which way A is going. It is just this which both most desire to know, for upon it must depend their tactics; upon it must depend the best measures to be adopted to avoid collision; it is just this which neither can tell; it is just on this point, in this particular, that the mistake, the misapprehension, the error in judgment occurs, which is the source and mainspring of the accident. Neither vessel can know the course the other is steering. They *can* see and judge of this in the day-time, but not at night, notwithstanding the lights which all vessels, of whatever nation, are now obliged by law to carry; and this no doubt is the principal cause why collisions are most frequent at night. Could it be known at night, as it is in the day-time, what course a vessel in sight is steering, it is plain that the probability of collision at night would be reduced to nearly the

same level as in the day-time; and could a vessel at night observe the change of course made by another in her proximity, as she can in the day-time, the advantage of daylight for the avoidance of collision would depend principally, if not entirely, upon the distance at which the course, or change of course, of an approaching vessel could be observed.

Before illustrating this by a case, it will be necessary briefly to state the present system of lights. The regulations as to steam-ships are these:—

Art. 3. Sea-going steam ships when under way shall carry:—

(*a.*) *At the Foremast Head*, a bright White Light, so fixed as to show an uniform and unbroken light over an arc of the horizon of 20 points of the compass, so fixed as to throw the light 10 points on each side of the ship, viz., from right ahead to two points abaft the beam on either side; and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least five miles.

(*b.*) *On the Starboard Side*, a Green Light so constructed as to throw an uniform and unbroken light over an arc of the horizon of 10 points of the compass; so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side; and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least two miles.

(*c.*) *On the Port Side*, a Red Light, so constructed as to show an uniform and unbroken light over an arc of the horizon of 10 points of the compass; so fixed as to throw the light from right ahead to two points abaft the beam on the port side; and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least two miles.

(*d.*) The said Green and Red Side Lights shall be fitted with inboard screens, projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

These are the rules at present in force. You will observe that there is no regulation regarding the height at which the white light is to be carried, nor is there any rule as to any relative position of one light to another, or between all the lights. If the white light is at the foremast head, the red light anywhere on the port side, and the green light anywhere on the starboard side, the terms of the Act of Parliament are complied with. In practice, the *spirit* of the law is acted up to, rather than the letter; and it is found more convenient and less expensive to hang the lanthorn which should represent the white mast head light, at an easy distance down the forestay; so this is the arrangement in most merchant vessels, and it appears to be nearly as efficient as the more strict conformity to the letter of the Act, which is less frequently adopted. As regards the side lights, they are placed in different vessels, as was remarked to me by a friend, in every conceivable position between the hawse-pipes and the taffrail; and yet these at any rate are, notwithstanding their irregularity, in strict conformity with the regulations; they are on the side of the vessel, and that is all that is required of them.

Such being the rule, and such the corresponding practice—for here rule and practice are not at variance—let us examine the effect. A (Diag. 1) at night sees on her port bow the white mast head light, and the green light of another steamer B. This stranger may be approaching on a course nearly opposite to that of A. Her red light, though

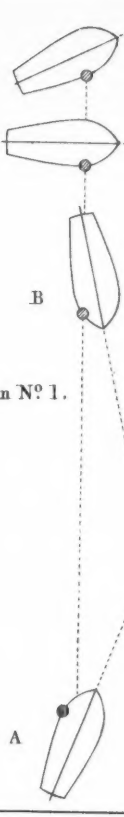


Diagram N° 1.

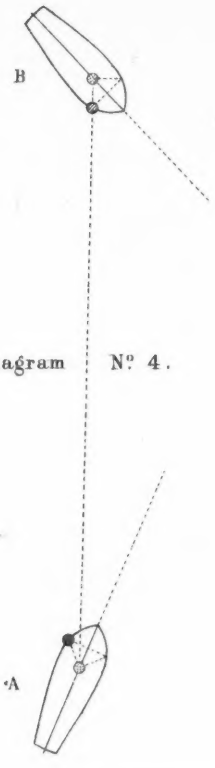


Diagram N° 4.

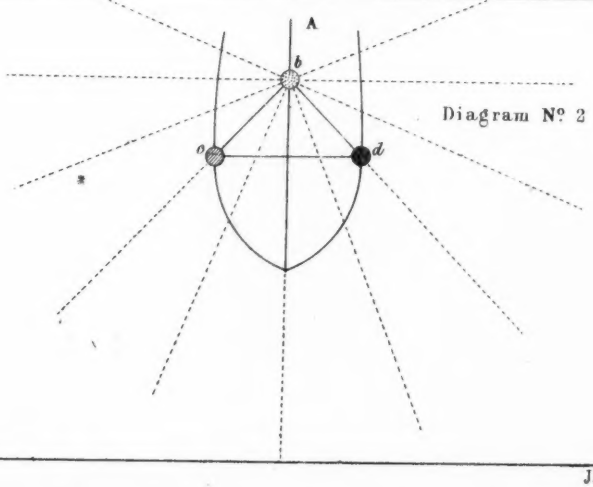
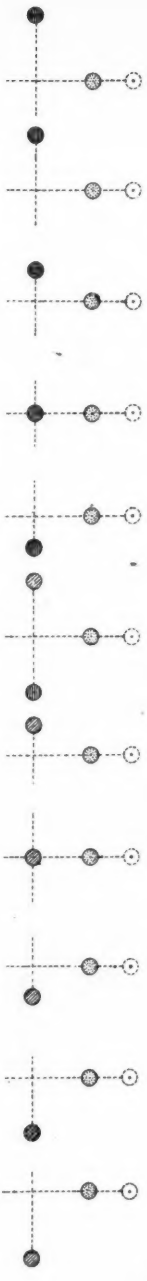


Diagram N° 2

Diagram No. 3.

A Steamers lights as they would be seen under the arrangement of the lights now in use by which the mast head light in its transit with the side lights will give a line of sight of four points or 45° on either bow.

N. The second position of the bright light shown by the dotted outline is that which it would occupy if its height were regulated by the second proportion named, instead of the first



Vessel steering 10 points to the left of the line of bearing; or if bearing North is steering W.N.W.

Vessel steering 8 points to the left of the line of bearing; or if bearing North is steering West

Vessel steering 6 points to the left of the line of bearing; or if bearing North is steering W.S.W.

Vessel steering 4 points to the left of the line of bearing; or if bearing North is steering S.W.

Vessel steering 2 points to the left of the line of bearing; or if bearing North is steering S.S.W.

Vessel steering directly on the line of bearing; or if bearing North is steering South.

Vessel steering 2 points to the right of the line of bearing; or if bearing North is steering S.S.E.

Vessel steering 4 points to the right of the line of bearing; or if bearing North is steering S.E.

Vessel steering 6 points to the right of the line of bearing; or if bearing North is steering E.S.E.

Vessel steering 8 points to the right of the line of bearing; or if bearing North is steering East

Vessel steering 10 points to the right of the line of bearing; or if bearing North is steering E.N.E.

Red is shewn thus ●
Green " " ◍
Bright " " ○

not observable, may be only just shut out and half a point from the direct line of approach is sufficient for this. But it is equally probable that B may be crossing the path of A at right angles, or she may be steering a course only four points different from that of A herself. That is, if A is steering N.N.E. and sees B's lights bearing north, B may be rapidly nearing A on a S. by E. or S. half E. course, or, she may be steering any other course between that and E.N.E.

And it is impossible for A in any way to divine, under the present regulations as to lights, in which of these different directions B may be proceeding.

And B is equally in a dilemma as to what course A may be steering.

Now take a case which has actually occurred, and I will select one where the vessel was run down and sunk in a few minutes,—a case of which the facts have been thoroughly well sifted: for they have engaged the attention of some of the first lawyers of the day, which, nevertheless, exhibits the usual characteristics of a conflict of evidence, and explanations unsatisfactory on some most important points. Off Cape St. Vincent, on a November night, a few years ago, the "Araxes," going from England to Gibraltar, met the "Black Prince," going from Gibraltar to England. The "Black Prince" appears to have been rather to the westward of the other, or farther from the land, and, believing she could do best by keeping outside the strange vessel, she altered her course still further to the westward. The "Araxes," on the contrary, first sighted the "Black Prince" nearly ahead, and therefore ported her helm, as directed by the statute; that is, she also went to the westward, and in doing so ran into the "Black Prince," cut her down and sunk her, and property to the amount of £25,000 was lost. Another very similar case has more recently occurred in the channel, where the "Murillo" was run down by the French steamer "Dix Décembre," when three lives were lost and property to the amount of £60,000. The circumstances of this case are nearly similar to the last. Of course neither vessel tried to run the other down, they both endeavoured to their utmost to *avoid* collision, and to this end they adopted the measures which each thought best, both being ignorant of the course the other was steering. But there was an error in judgment, a misapprehension on one side or the other, or on both sides, and the result was a fearful destruction of life and property. Both vessels would have gone clear of each other in the daytime, and why? because they could see the way the other was steering; and it is impossible to suppose that these accidents could have occurred had each vessel, although at night, been able to know the course of the other, and to observe and note any change of course made by the other.

And to shew the absolute necessity of knowing the course which an approaching vessel is pursuing in order to avoid collision, it will be only necessary to quote one more example. A sees nearly ahead the green light of another steamer, B, which she supposes to be coming nearly end on to her, she therefore, in accordance with the statute, ports her helm, and expects that B will do the same, which no doubt she would do if she *were* coming nearly end on, and thought that A was doing the same; but B instead of coming nearly end on

to A, is really steering a course nearly at right angles to that of A, and this being the case, it is plainly not the best thing that A can do to port her helm, and yet A, in porting her helm, is acting up to the regulations, and to the best of her judgment, but by doing so, is *seeking* a collision, while trying to avoid it. She has committed herself to a manœuvre which she would not have contemplated for an instant, had she been able to ascertain and know B's course—the direction in which B might be steering.

The manner in which I propose that vessels may be enabled to know, at night, the course another is steering, with nearly the same accuracy as in the daytime; and may also be able to observe any change of course in another, is, as I mentioned at the outset, by an improved system of lights, or rather by an improved arrangement of the lights already in use.

I am well aware that any system of lights, whether this or any other, to be of any good effect, must be of general adoption; and to obtain anything like a general adoption, or to hope to obtain it, the system proposed must not only supply a recognized want, but must do so efficaciously, simply, and inexpensively.

I think the necessity of the knowledge which this system proposes to supply cannot be denied; whether the want is met as it should be, and whether the proposed system possesses to a sufficient degree the indispensable qualifications of simplicity, efficiency, and inexpensiveness, it will be for the meeting to judge. The proposed arrangement, at any rate, is a very simple one, were it not so I could not consider it of any value whatever; it will, therefore, take but a very short time to describe. It consists in regulating the present lights in fixed positions with regard to each other, and in so placing them that the side lights when seen directly beneath the masthead light shall give a line of sight of 45° or four points on either bow of the vessel observed; and further that the height of the bright light above the level of the side lights be always in a fixed proportion to the distance between the two side lights. The rule then for placing the side-lights would be this. The line between the side lights being at right angles to the keel, that this line be at a distance before, or in front of, the mast-head or bright light equal to half the distance between the side-lights. Let A (diagram 2), be taken to represent the fore part of the deck of a steam-vessel, *b*, being the place of the foremast, *c* and *d* represent the proper positions of the green and side lights respectively. By this arrangement there will be obtained three distinct and important lines. The one right ahead when all three lights are visible, and one on either bow at an angle of 45° or four points when neither side light is seen directly under the white light. And for the purpose of estimating the remaining points of the compass at which the lights may be seen, a fixed proportion of the height of the mast-head light to the distance between the side lights is necessary; and the most simple proportion for this purpose, the proportion which would give the estimate desired, most readily, and be the most valuable for the object in view, would be, that the height of the bright light above the level of the side lights should be equal to half the distance between

the side lights. This proportion might possibly, in small vessels, place the white light too low; but that the proportion be the same in large and small vessels is essential.

Perhaps another convenient proportion would be, that the three lights, when seen directly ahead, shall form the points of an equilateral triangle. The effect of the lights, with either of these proportions for the height of the mast-head light, is shewn in the accompanying diagram No. 3; the first proportion (or that of height above level of side lights, which equals half the distance between the side lights, and which I believe to be best,) is shewn with the outline of the light fully marked; in the other the outline is dotted. Let us now examine the working of this system.

A (diagram No. 4), steering N.N.E., sees on her port bow a bright light directly above a green light, bearing north; she at once knows that a steamer, B, is crossing her bows, steering S.E. She observes the green light gradually to draw out to the right of the bright light, and she then knows that B is altering her course to the eastward;—or, if the green light opens out to the left of the bright light, she knows that B has ported her helm, and that there is danger of collision. Or, B sees on her starboard bow, bearing south, a red light open to the right of the bright light, she then knows that a steamer, A, is approaching her on a course between N. $\frac{1}{2}$ E., and N.E., and by the degree at which the lights are open, one from the other, she will be able to judge, within a point or a point and a half, the actual course which A is steering; and she will, also, be able to discern directly any alteration of course which A may think fit to make. If A starboards her helm, the red light will become more open of the bright light until the green light of the starboard side is seen; but if she ports her helm, the red light will close with the bright light until they are in one line. On the system, as at present carried out, neither B's nor A's course could be estimated within nearly ten points; whilst under the arrangement now proposed B's course is known exactly; and A's course, her position being nearly the most unfavourable possible, can be ascertained within a point, or a point and a half at most. Where the least degree of accuracy is attainable is where it is least required, that is when the vessel seen is steering at an angle greater than 90° to the line of bearing.

This simple system would, I think, tell readily and unmistakeably the course steered by vessels sighting each other at night with nearly the same accuracy as can be known in the day-time. Any system of lights to be really valuable must be so simple as to be read at a glance, and as plain as to admit of no misinterpretation, and I trust that the arrangement now proposed may be found to fulfil these requirements, and may thus be a means, if generally adopted, of greatly decreasing the danger of navigation, and particularly of preventing some of the numerous and disastrous collisions which are now becoming of such frequent occurrence.

The proposition which I wish to lay before you and invite you to discuss is then shortly this:—

1st. That vessels approaching one another, in order to determine

what measures are best adapted to avoid collision, must know approximately, that is within two or three points at most, the course the other is steering; and that the want of this knowledge is a fertile source of collision.

2nd. That the present regulations, with regard to the lights carried by steam vessels, do not enable even an approximate knowledge to be gained, at night, of the course steered by the vessel whose lights are seen.

3rd. That an improved arrangement and regulation of the lights already in use, such as that now suggested, would supply this want; and by enabling a correct judgment to be formed of the course steered by an approaching vessel as soon as her lights are seen, would be calculated to lessen the liability of collision.

I must apologise for the roughness of the diagrams and for the imperfections of my explanation.

I beg to tender you my best thanks for the kind attention which you have given to this subject, and I shall esteem it a favour if gentlemen present will kindly state their opinions on the proposition. I shall of course be most happy to answer any questions or give any further explanation that may be desired.

Captain HEATHORN: I should like to ask if the fact of a vessel being very much down at the stern would not alter the position of the triangle?

Commander HEATHCOTE: Mathematically, yes, but not practically.

Commander COLOMB, R.N.: I wish to make one or two remarks. I have listened with a great deal of interest to the paper just read, and I must say that I fully agree with every single word which has been uttered. I think it one of the most important subjects that we could discuss in this Institution. The commerce of England is increasing round our shores every year; the speed of our ships is increasing; the numbers which are collected round the centres of our commerce are becoming so enormous that really the chief danger a ship has to encounter, in bringing her wares to the market where they are to be sold—that is England—is the danger of running foul of or of being run into by other ships, who are also bringing their wares to the same mart. I will endeavour to make my remarks as short as possible, though, unfortunately, I have a good deal to say, because on a former occasion I had the misfortune to stand in Mr. Latham's way (who is to read the second paper this evening). When I heard his paper afterwards, it was such an uncommonly good one that I bitterly regretted the abridgment which I caused. I hope I shall not do it again. While agreeing with every word which has been said by the lecturer, as to the placing of permanent lights, and thinking really that there can be no question about it, that being a measure which should be carried out immediately, there is positively no objection to it—while agreeing with all that he has said in that way, I still think that our system of permanent lights does not meet all the requirements of the case—does not prevent all the danger of collision, which one would expect from them. I should class collisions at night under three heads, supposing, of course, that every ship carries her proper regulation lights. The first would be when either from a bad look-out or from the thick weather no lights whatever are seen, which I believe is the commonest case of all. The next class would be when the lights are seen, but through particular states of the atmosphere or other causes, such as colour-blindness on the part of the look-out man, the red light and the green light are mistaken; or it may be that a white light is mistaken for a green light. The last class where collisions occur would be when the lights are fully made out, but when an approaching ship thinks it is better not to follow the rule of the road from other reasons. When a collision is nearly inevitable there is always a certain moment of doubt, and that moment of doubt is very often fatal. You have

to exercise your judgment in an instant as to what you are to do. We had one case mentioned by the lecturer, the "Araxes" and the "Black Prince." It was a case in point. There was another case much nearer home, between the "Helen Sinclair" and the "Minna," where the "Helen Sinclair" was sunk; that was precisely a similar case, off Erith, in the Thames. The "Wanato," and the "Samphire," and the "Fanny Buck," were cases of the first description of collision that I have mentioned. It seems to me that one great desideratum would be, if it were possible, to increase the power of our lights, so as to force a look-out man, however much he might be inclined to doze over his work, and however bad his look-out might be, to understand that a certain coloured light was showing in a particular direction. The next thing that is wanted would be something by which a ship, feeling that she was obliged to depart from the rule of the road, should be able to announce at once to another ship approaching her that she was so departing from it, or, it might be, that she was following the rule of the road. I have considered it quite impossible to increase the power of permanent lights, but a subject to which Captain Bolton and myself, about ten or eleven months ago, turned our attention, was the endeavour to provide something like temporary lights: to supplement the permanent lights but not by any means to supersede them, because with the improvements which the lecturer has suggested, they would be as perfect as permanent lights could be. But we want something stronger. I believe in the majority of collisions the ship which is about to receive the blow is perfectly aware of it for some minutes previously. That was so in the case of the "Samphire;" I believe it was so in the case of the "Wanato;" and certainly it was so in the case of the "Helen Sinclair" and the "Minna," in the Thames. Now, it has always struck me that it would be desirable to have some signal which you could make at once to an approaching ship, if you saw that she was likely to come into collision with you, you being on the right tack, or if the case were such that you were not able to alter your helm; it would be desirable to be able to say to her at once, "Here I am, steering in such a direction." For this purpose one would provide these lights. Or, again, if you wanted a signal to say, "I am in doubt about the way you are steering; I am putting my helm a starboard; make the best of it, and alter your course." Now we have here three pyrotechnic lights; they are coloured red, white, and green. They are distinguished, the red having a single ring on it, the white having a double ring, and the green three rings. They are kept in an air-tight box on deck, of convenient shape, so that it can be placed where it is most convenient. It is supposed you see a ship coming down upon you, say on the port side; you are close hauled, or lying to, or have stopped your engines, and you perceive something coming. She does not perceive your red light. You have this, which is an enormously powerful red light. There is a little plug on the top; by pulling out the plug you produce the light at once. It seems to me that the person in charge of the other vessel would—seeing a bright red light—port his helm at once. Again, if you are approaching another ship end on, and you are going to follow the rule of the road, and are not quite sure what he is going to do, you burn a red light, and "Port your helm!" He sees your red light, and he ports his helm without any further consideration. It seems to me that in a great number of these cases, had we had something of this sort, collisions might have been avoided. These pyrotechnic lights are here for any gentleman to look at. We cannot fire them here, because it would be rather a choking proceeding; but after the lecture, if any one would like to see them burned, we can burn them outside.

H. C. Rothery, Esq., Registrar, Admiralty Court: With the permission of the Chairman, I should like to make a few remarks upon the very able paper that Captain Heathcote has been reading to you. The only point about which I have any doubt, and it is one to which a great many of Captain Heathcote's observations applied, is, as to the relative height of the white light and the two coloured lights. He said, if I understood him correctly, that the lights should be so placed that they would form an equilateral triangle. Perhaps Captain Heathcote will be good enough to say whether the height of the white light above the deck will make any difference at all? Because, if I understand his system correctly (and I think it is impossible for anybody to have paid any attention to it and not to have seen the great value of the system), the importance of it is this; if you see a red

light and a white light of a vessel, you will know, of course, that you are on the port side of that vessel; if you see the red light and the white light in the same vertical line, you know that you are four points on the port bow of that vessel. If you see the green light and the white light in a vertical line, you know you are four points on her starboard bow. But whether the white light be one foot, or two feet, or three feet, or twenty feet above the coloured light, if you see them in the same vertical line, I do not very well understand what difference it would make. These are the only observations I would wish to make.

Captain CRAUFURD, R.N.: As a practical man I should like to say a few words, for we must look at these things practically as well as theoretically. As to the height of the light, whether it is ten feet or twenty feet, I will put it to any sailor present whether he will know the difference. So far as I am able to pronounce an opinion, the fact of having one coloured lamp on one side of the ship, and another coloured light on the other, and a different coloured light at the mast-head, which light distinguishes steamers from sailing vessels, puts you in the position of knowing exactly what ship is coming to you. This is a point clear and well defined. All these things look very pretty theoretically, but I am afraid that in actual practice these laws are not carried out as they ought to be carried out. Coming up the channel about ten days ago, on my return to England, steering a straight course in a steamer, going nine knots, we came across several ships, and not a light was shown on them. Now I will put it to you if a collision had taken place, would it have been surprising? The lights of the steamer I was in were shewn; the mast-head light, the red and the green. These other ships, I suppose, when they came near us, had a great hustle and bustle on board to show a light. Of all the means of preventing collisions, there is one thing that ought to be depended upon more than anything else, and that is the eye of the seaman. You may see green lights, you may see red lights, and you may see white lights, but if you do not keep a good look-out, what is there to prevent collisions. I do not wish to say anything against the theory of the lecturer, but I doubt whether any advantage is gained by the actual height of the light, or whether the white light is at a certain angle with the red light or the green light. The man must have, first of all, a good eye. Coming up channel, I have often wondered that more collisions have not taken place. I think that those who keep their eyes well open will have no trouble in keeping their ships clear of others.

Mr. STIRLING LACON: You say you did not see the lights in those ships; was it that they were not carrying lights at all?

Captain CRAUFURD: Carrying no lights at all, or at least showing none; this I am perfectly sure of. I happen to be a little curious about things; and I did not go to bed very early, but walked on the deck. I saw these ships, and had my glass to look well at them. I have been absent from England about three years, and I had thought the law was stringent enough. But if the law is not stringent enough, steps ought to be taken to make it more stringent; and there ought to be a heavy penalty upon ships at sea for not showing lights. In a foggy night in the channel, if ships have not their lights, what is the use of telling them to carry lights. I say there ought to be a heavy penalty; and that all ships ought to be reported which do not carry lights; which, if carried and seen, would prevent many of the collisions that take place.

J. A. HARPER, Esq.: It is my ill fortune to have these cases to deal with. I know that persons have represented to me that collisions which take place are frequently the consequences of a careless attention to the rules of the road; and I know that a great many persons have to pay very large sums of money from negligence in the observance of the rules of the road, or from causes which Captain Heathcote has pointed out to-night, and from imperfection in the rules of the road in several cases. And a great amount of property is destroyed for which no remedy is ever obtained, because of the uncertainty of this very rule of the road. But I understand that the question to-night is confined to the question between steamers. The fact that the gentleman who spoke last has come up the channel in a steamer and seen a great number of steamers without a light, is scarcely the point to-night. It may be a question for discussion another evening, whether some alterations may not

be made in order to give greater protection to sailing ships with respect to each other, and to steam-ships with respect to sailing-ships. But the simple question, as I understand it, to-night, is a question between steam-ships. I do not think the gentleman who spoke last was here at the commencement of Captain Heathcote's address. I think he said he came in at a late period. It is quite plain he did, because he seemed to treat a point which he thinks is in Captain Heathcote's system as important, which is quite incidental to it, not vital and not necessary to it at all; and with respect to which a blot has been hit upon and exactly described by Mr. Rothery, which has no importance excepting so far as relates to the introduction of a new system of lights. Mr. Rothery will be glad, no doubt, to contribute to any other system which will have the effect of making it a good working system. It is not essential to Captain Heathcote's system at all, that the white light should be at a fixed height above the other. As I apprehend the point, it really has nothing important to do with the question. The great question is the relative position of the white light and the coloured light solely; and Captain Heathcote has explained, that a vessel approaching another may see in a moment by the relative position of the white light and the green light, or the white light and the red light, the course which that ship is steering; and also may see in a moment, under ordinary circumstances, not the extraordinary circumstance of an intense fog, when no human precaution can be taken, but under ordinary circumstances may discern in a moment the slightest change in the course of the vessel approaching, and shape her proceedings accordingly. Captain Heathcote has suggested a system which it is quite evident will work with infinite accuracy, namely, the placing the white light in such a position that the line of vision between the white light and any one of the coloured lights will show that the keel of the vessel is at four points, *i. e.*, that she is steering a course 4 points from the reverse side of bearing. Any one seeing those lights will know in a moment the exact course of the vessel. And it is quite plain that if that course is any other—if the line of vision forms any other angle than that four points, you can observe it to a nicety, and you will also detect the slightest change. If she ports her helm, you will see that in a moment; if she starboards her helm, you will see that equally. When I say in a moment, I mean in sufficient time to enable you to alter your course accordingly. I think scarcely anybody is aware of the enormous consequences of the establishment of any signal system by which one ship can ascertain the course, and the change of the course of another ship approaching. A vast amount of property is imperilled almost every night by the want of some such system. It is quite impossible for a ship seeing the lights of another ship, as they are arranged now, to get such an indication as will enable her to guide her way. They just know one single circumstance. They see the port or starboard light of a ship, and anything more than that they know not. They discover the relative position of the two ships when it is too late to avoid a collision. Then, I must say, you must have a stronger light when you are approaching a ship, a stronger red light at the spot where the red light should be, and a stronger green light at the spot where the green light should be. That would be a very important portion of Captain Heathcote's system. Almost all maritime countries have adopted the rule of this country; and I have no doubt it would not be exceedingly difficult to get a general concurrence to a change in the law of this country.

The CHAIRMAN: No change is required.

Mr. HARPER: The establishment of such a system then will not be so difficult as I anticipate.

Mr. PRITCHARD rose to offer some observations.

The CHAIRMAN: I know there are some gentlemen present who are anxious to hear Mr. Latham's paper on gun-cotton cartridges, and I believe they would like the present discussion to be closed for this evening; the question will no doubt be brought before the Institution on another occasion. I will now call upon Captain Heathcote to reply.

Captain HEATHCOTE: I think the chief question raised was about the height of the white light. The principle of the height is necessary in this particular. This being the position of the lights, when they are seen in one line, or one beneath another, the four points, or 4·5 degrees of angle, is very well defined. But the

question is to measure, to judge, and to estimate the intervening angles, that is an angle between the four points and the end on or between four points and any greater angle. For that reason the proportion of height is necessary; because if the proportion varied, the angle between the lights when seen obliquely would be very different. For instance if one ship adhered to this proportion, she would show her lights, at two points, in the position shown in the diagram; whereas, if another vessel showed her bright light at a lower level, she would show it at a different angle, and thereby represent herself as steering a different course. For that reason proportion is necessary, and for no other. But the particular proportion of the equilateral triangle is not essential, the principle being that a proportion be fixed and universal.

Mr. ROTHERY: Quite so. Captain Craufurd's principal remark was about the necessity of a good look-out and a good eye. I believe it cannot be disputed, that with the best eyes and the best look-out, you cannot tell a ship's course. That is the case. I do not think I have made any mistake in that diagram (No. 1). The green light there shows nothing; you may keep as good a look-out as you can, and yet the green light will show you nothing except that the starboard side of the vessel is presented towards you, from a line very nearly ahead to ten points round the compass. It is no guide to the course of the ship; and it is necessary to know the course of a ship to avoid collision.

Mr. HARPER: One remark. With respect to the height, it seems to me that the lower the light, the more distinct it would be.

Captain HEATHCOTE: That is what I say. I believe the equilateral triangle is not the best. The better proportion is when the height of the mast-head light is equal to half the distance between the side lights. You will observe that with this proportion the angles are more easily read than with the equilateral triangle. But a possible objection to that occurs to me, that the white light, at that height above the level of the side lights, might in small vessels be too low.

The CHAIRMAN: I must confine myself to very brief observations. I feel perfectly certain that we have not had sufficient time to discuss the subject on hand, for we have only partially entered into it. I trust it will be resumed another evening this session. I would only say at the present moment, with respect to the difficulty of placing the red and white lights before the foremast, I see a difficulty in trimming them when you get into a sea. That is a difficulty which, as a practical seaman, I am afraid of. I will not detain you any longer, except to ask you to join me in a vote of thanks to Captain Heathcote, for the able manner in which he has brought this matter forward.

GUN-COTTON CARTRIDGES—PRENTICE'S SYSTEM.

By MR. JOHN LATHAM, 27, Pall Mall.

IN bringing before you this evening a short description of the new gun-cotton cartridges which have been lately introduced for breech-loading arms, and which are undoubtedly the first successful application of this material for sporting purposes, I feel that a few words are necessary to explain what may appear to be presumption on my part in undertaking a subject on which you have had so much previous information. In Mr. Abel's admirable lecture delivered in this Institution two years since, you have the fullest account of the chemistry of the subject, and into this I do not propose to enter, except as far as may be necessary to explain the reason of the mechanical arrange-

ments adopted. In short, I can only profess to give you my own experience as that of a practical gunmaker who has taken great interest in the application of this material to small arms, leaving aside the questions of its employment for artillery and blasting purposes, as well as the chemistry and philosophy of the subject, which have already been brought before you by gentlemen better qualified than myself to deal with these points.

You will remember the excitement with which the news of Professor Schönbein's discovery was hailed when it was first made known in 1846. The superior power, the cleanliness, and many other advantages of the new material, and the ease with which it could be manufactured in small quantities, set all the world experimenting with it, and nothing less than the speedy abolition of gunpowder was expected. Under the direction of Mr. Henry Wilkinson, I was one of the number who entered eagerly into a course of experiments, and soon became aware that the management of this new projectile force was by no means the easy matter which at first it appeared to be. On two occasions the cotton I produced exploded in the process of drying in a water-bath, at a heat considerably below 200°. Some other specimens, prepared with the same manipulation, could hardly be induced to explode at all. Even when an apparently definite product had been obtained, its behaviour as a projectile force was extremely capricious. At one time 15 grains of cotton would send a 30 guage bullet through three inch deal planks, giving as much projectile force as 50 grains of gunpowder, and the very next shot with the same weight of the same cotton would hardly have strength enough to indent the wood. But the advantages of the new material, when it could be induced to do its work properly, were so great that an attempt was at once made to introduce it commercially, and the patent was purchased by Messrs. Hall, the well-known gunpowder manufacturers at Faversham, who established a large factory for its production. I have here specimens of gun-cotton procured from them in 1846, which, after the lapse of 20 years, have lost none of their original qualities. These specimens are all of cotton wool, which was the only form of the material then employed, and one of them, as you will see, is coloured blue, a plan which was proposed to avoid the chance of accident from the resemblance of the explosive cotton to the ordinary material. The charges employed for sporting arms consisted of 20 grains by weight of this cotton wool, slightly compressed, so as to form a ball, and glued to a wad which fitted the gun. This charge was used with one ounce of shot in a 16-bore muzzle-loader, and made very good shooting, though too irregular to be depended upon. Gun-cotton was also employed for blasting purposes, but some lamentable accidents which occurred in the filling and "tamping" of the holes brought it into discredit, and finally the explosion of Messrs. Hall's factory, with the loss of several lives, caused the manufacture to be abandoned. About the same time experiments in France and Germany were brought to a close for similar reasons. Spontaneous combustion was suspected or feared. I am not aware that it was ever definitely proved, but the idea of gun-cotton as a practical agent was given up, and it was only

brought forward in lectures on gunpowder as a type of all that was most to be avoided as a projectile force.

In short, having become aware that gun-cotton, when used in the same way as gunpowder, was too dangerous and uncertain to be employed, the question was left, in England at least, without further investigation for nearly fifteen years. In the meantime, Mons. Montigny, the well-known gunmaker of Brussels, introduced a breech-loading rifle on the needle principle, in which he enclosed a small charge of gun-cotton in the body of the projectile, and the thrust of the needle piercing through this body of cotton ignited a small pellet of fulminating powder in front. We can now see by the light of our present experience that he could not possibly have devised an arrangement better calculated for bursting the rifle in which such a cartridge was fired, and this was actually the case in so many instances that this plan was soon abandoned. The only other attempt that I am aware of to revive the employment of gun-cotton was made in 1855 by Captain Norton, to whose fertile invention we owe the first indications of so many of our modern improvements in gunnery. I have here a specimen of Captain Norton's cartridge; the charge of gun-cotton rolled into a ball is enclosed in a covering of paper with netting outside, the arrangement bearing a considerable resemblance to the plan at present adopted for sporting cartridges.

It must not be supposed, however, that because gun-cotton was abandoned for projectile purposes its manufacture was discontinued. Its employment in photography as the base of the well-known collodion caused a constant demand for it; but it was found at first as capricious and uncertain a servant for artistic as for military purposes. Some spoke of a "solution of gun-cotton in ether," whilst others found their gun-cotton obstinately refusing to dissolve in that substance. Other extraordinary anomalies in its action were found, and the whole subject was obscure until the publication in the Journal of the Chemical Society of an elaborate series of researches by Mr. Hadow, of Bristol, which were conducted in the laboratory of King's College, London. He first showed us the true chemical constitution of pyroxyline, and established the fact of there being at least four varieties produced by the usually received process—the differences being caused by variations in the strength of the acid used, the temperature of immersion, &c. He designated those varieties by the letters A, B, C, D. Of these the first compound A is the most explosive, containing the largest amount of peroxide of nitrogen, and is insoluble in ether. This is produced by the strongest acid which can be employed, and this compound which Mr. Hadow holds up to the avoidance of all good photographers is the only one with which we are interested in gunnery. But the value of his researches is this, that it is precisely the presence of the lower compounds B, C, and D, which, however valuable they may be in photography, have given rise to many of the defects of the old gun-cotton. These explode at a very low temperature, and are liable to spontaneous decomposition, if not combustion, by keeping. It was, therefore, a great advance when we learnt from Mr. Hadow how to avoid these in our gun-cotton.

But our difficulty with regard to the capriciousness of the force produced still remained; we could hardly tell when we ignited a charge of gun-cotton what the result would be, and as one, at least, among the possibilities was the bursting of the gun, it is not surprising that the experimentalists were few. In short our knowledge of gun-cotton up to 1862 may be summed up in the words of a German writer of that date, of which the following is a translation:—

"Gun-cotton," he says, "is an ideal force, a non plus ultra force. Incapable of any modification, he is a stubborn '*mauvais sujet*' of noble family, who, wherever he makes his appearance, behaves with terrific violence, and won't accommodate himself in the least to existing arrangements, conducting himself like an autocrat or a revolutionist of the first order, he demands that everything shall consult his convenience, that the whole edifice (of our fire-arms) raised upon the basis of centuries shall be overturned because, forsooth, he has appeared on the scene."

About 1862 it became known in England that gun-cotton had been in use in Austria for some years, and that certain modifications introduced by Baron von Lenk, a general officer in the Austrian army, had proved so successful that the whole of the artillery service had been adapted for its employment under the direction of that officer, who published in 1862 a work under the title of "Das gezogene Schieszwollfeld-und Gebirgsgeschütz" (nach Lenk's System).

As this showed that considerable progress had really been made, Mr. Abel, Chemist to the War Department at Woolwich, was commissioned by the English Government to examine into the subject, and that gentlemen has himself laid before you the results of his investigation. Without entering into the chemistry of the subject, I may briefly state the principal points in which we are indebted to General von Lenk for an advance upon our previous knowledge.

If the process given by the original inventor, and detailed in the patent taken out in England by John Taylor, in October, 1846, be strictly followed, the resulting compound is undoubtedly the most explosive form of gun-cotton, and the specimens I have shown you prove sufficiently that this substance is permanent and unaltered after a lapse of twenty years. But the substance then employed—loose carded cotton, or cotton wool as it is generally termed—cannot be sufficiently modified in its mechanical arrangement to produce the result we want in a projectile force, viz., a gradual combustion or evolution of gas, as distinguished from instantaneous combustion or explosion.

General von Lenk obtains the controlling power required by the simple expedient of employing cotton in the form of loose yarn or thread which is afterwards woven into cord, thread, or hollow braid, according to the rapidity of combustion which he requires. By this means he effects for gun-cotton an improvement similar in kind, but even more extensive in effect than the improvement which is effected in gunpowder by the process of granulation, and he is enabled to modify the rate at which the gun-cotton will burn from the most violent detonation down to simple combustion. Another and very curious

point which he established was this—that the explosion of gun-cotton is materially affected by the manner in which it is lighted. Thus if lighted with a large flame or great body of heat, the combustion is vivid and intense; but if only a small spark be applied the result is apparently a rapid smouldering of the material without any flame. You will see how this peculiarity affects its use in fire-arms, since a copper cap of double the usual stength may start the combustion of this material so rapidly as to render it uncontrollable, whilst a cap that hangs fire from damp or other causes may cause the charge to lose much of its force.

For cannon and small-arm cartridges Baron von Lenk employed gun-cotton yarn twisted tightly round a hollow cylinder or spindle of wood, so that the combustion proceeded from the exterior surface towards the interior of the cartridge. For quick-match and bursting charges for shells he employed hollow braid, in which the burning gases, traversing the interior of the material, cause a more rapid and intense combustion such as you have seen in the previous experiments.

In 1863 a short account of General von Lenk's discoveries was read at the meeting of the British Association, at which Mr. Prentice, of the firm of Messrs. T. Prentice and Co. of Stowmarket, in Suffolk, was present. Messrs. Prentice have for years been largely engaged in the manufacture of artificial manures, and employ great quantities of nitric and sulphuric acids in their business. Mr. Prentice entertained the idea of establishing a manufactory of gun-cotton at his works, and no small portion of the success which has been achieved in England is owing to this fortunate circumstance, whereby the manufacture has been undertaken by a gentleman already thoroughly conversant with the chemical properties of the substances employed, and who has been thus enabled not only to reduce the necessary dangers of the manufacture, but to introduce important improvements in the application of gun-cotton. The works extend over nearly an acre and a half of ground, traversed by a stream of running water, which is employed for washing the cotton and for filling the magazines, for the stock of this material is kept constantly under water from the time of its manufacture until it is required for actual use. You have here specimens of the cotton as it is received at the works in the form of coarse loosely-spun yarn and fine thread. These are first freed from dirt and grease by dipping in a hot solution of potash, and thoroughly washed and dried before transferring them to the bath of the mixed acids, in which they remain for forty-eight hours, being kept cool during the process by the immersion of the jars in a stream of running water. The omission of this precaution was one great cause of the uncertain quality of the old gun-cotton, as, if the temperature be allowed to rise above 60°, there will be great danger of the formation of some of the lower and unstable forms of gun-cotton. On removal from the acid-bath the cotton is placed in a centrifugal drying-machine, which removes the surplus acid in the same way that a mop is dried by trundling it; the cotton is then thrown under a fall of water, and finally laid in running water for fourteen days to complete the washing. After a very dilute alkaline-bath it is finally immersed in a hot solution

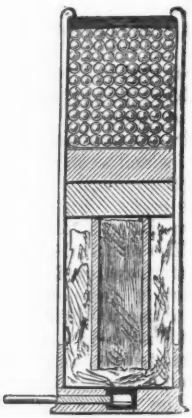
of soluble glass, of which it takes up a very small quantity. It is on the advisability of this process that our English chemists are at variance with General von Lenk, who recommends it, but as the only objection that can be urged is that it is probably useless, we may pass it over without further comment. After a final washing the cotton, which we ought now to designate by the formidable name of trinitro-cellulose, is in a fit state to be manufactured into cartridges. Every stage of the manufacture is carefully tested from day to day, and no precaution is spared to ensure the perfection of the results. The thread, whilst still wet, is woven into solid or hollow braid, and stowed under water until required.

These specimens will give you a clear idea of the mechanical means by which the combustion may be modified to any speed of explosion required, and you will remember that to produce a propelling as distinct from a shattering force, we require the slowest form of combustion. But there is one point more which requires attention, and without it we shall still be unable to get regularity of shooting. You may remember that in speaking of the earlier experiments with gun-cotton I mentioned the extraordinary variation in the results produced with equal charges of this material. The principal cause of this irregularity is so simple that it is only remarkable how it escaped attention for so long. I will explode a few grains of gun-cotton and an equal quantity of gunpowder, and you will notice the difference of the thin invisible gas produced by the one and the thick black smoke of the other. But in all the early experiments we were using the same wadding to confine both, and the consequence was that the thin gases of the gun-cotton often escaped past the wad without exerting any projectile force on the charge. To obtain the maximum effect with gun-cotton, it is necessary that the chamber in which it is exploded should be closed as perfectly as possible, and it is only when a very tightly-fitting and hard wad is used that regularity of shooting can be obtained. These conditions render it especially difficult to employ gun-cotton for muzzle-loading arms. The necessary tightness of the wadding requires greater force to ram it down the barrel, and if rammed in the least degree too hard, the mechanical arrangement of the cotton may be disturbed, and its rate of combustion altered. But in breech-loading cartridges these difficulties do not exist; and it is satisfactory to note that the improvements in our projectile forces keep equal step with the improvements in projectile arms, each assisting and supplementing the other.

The material employed in small-arm cartridges is the closely woven braid, but the rate of combustion in this is still too rapid. It is therefore enclosed in a small cylinder of waxed paper or cardboard (Fig. 2), and subjected to hydraulic pressure until it is compressed into two-thirds of its original bulk. This small cylinder performs two very important offices—first, by compressing the material it retards and regulates the rate of combustion, and it also directs the force of the gases upon the shot, and prevents, to a certain extent, the strain upon the sides of the barrel. If I light one of these cylinders you will see the steady regular flame with which it burns. But in the gun it burns at double

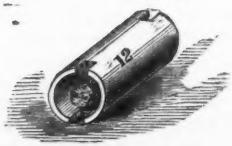
this rate because it is ignited at both ends, and to effect this, it is enveloped in a small piece of gun-cotton muslin, which communicates the flash of the cap instantaneously around it (Fig. 1). It is this combination of quick and slow combustion which is found necessary to produce the best results, and this arrangement is one of the improvements introduced by Messrs. Prentice on Baron von Lenk's system.

FIG. 1.



Gun-cotton Cartridge.
(Section.)

FIG .2.



Pasteboard Case containing
Compressed Gun-cotton.

These cartridges which have only been introduced during the past season for sporting purposes, have achieved a success which already great, will no doubt increase as they become generally known. Their advantages as compared with gunpowder are the lessened report, diminished recoil, and absence of fouling and heating of the gun. An animated discussion has taken place on the question of their safety, and I ought perhaps to say a few words on this. When used with the ordinary Lefaucheux double-grip action, and in a pair of good Damascus barrels, they are perfectly safe, but in some of the guns made in the present day with very light barrels, and especially if these are of any of the varieties of so-called "steel," greater caution will be necessary. For the new central fire breech-loaders, the cartridge must be specially constructed. In short, as you may judge from the extent and variety of the circumstances which affect the combustion of gun-cotton, it is very dangerous for any but the most experienced to make experiments with it.

It is obvious that the arrangement of these cartridges is open to some objection on the score of complication. It is not possible to vary the charge, since the addition of a few grains of gun-cotton unless all the other parts of the cartridge were modified to suit it, would throw

out the action of the whole. And this is at present one of the greatest obstacles to its general adoption. If the cylinder containing the compressed charge, and the muslin envelope could be dispensed with, and the combustion of the simple rope of cotton so controlled that all chance of the development of a shattering force be avoided, this rope could be safely supplied in length from which sportsmen could charge their own cartridges by simply cutting off the portion required, we should have overcome the greatest obstacle to the general employment of gun-cotton. I am happy to be able to state that there is every prospect of this desideratum being very speedily accomplished. A modification of the manufacturing process has just been patented by Messrs. Prentice, which, if it prove as successful as the first experiments indicate, will be the greatest step in advance which has yet been made in the employment of gun-cotton. All these complicated contrivances for regulating the combustion will be dispensed with, and all fear of a shattering explosion will be obviated. The cotton will be supplied in the form of a simple rope, which can be used with as much simplicity and certainty as the measuring of a charge of gunpowder. This improvement consists in weaving raw or unconverted cotton with the explosive material in sufficient quantities to moderate the combustion to the degree required.

By permission of the Council the case of specimens now on the table will be deposited for a short time in the Museum of the Institution. I have also a specimen of the new gunpowder, or rather gun-sawdust, lately invented by Captain Schulze, at Potsdam, in Prussia. As this has only just been received, I am unable to give you any information as to its projectile force in comparison with gunpowder or gun-cotton, but if I ignite a small charge of it you will notice the beautiful white flame with which it burns, almost rivalling magnesium in brilliancy, and the small quantity of residue left after combustion.

The CHAIRMAN: I am sure that I express the feelings of this meeting in giving our best thanks to Mr. Latham for the interesting paper he has laid before us.

Monday Evening, June 18th, 1866.

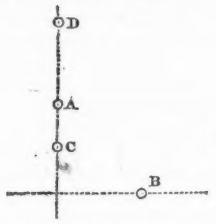
VICE-ADMIRAL J. H. CODRINGTON, C.B., in the Chair.

ADJOURNED DISCUSSION ON CAPTAIN HEATHCOTE'S PAPER.

The CHAIRMAN: Captain Heathcote has been kind enough to come here this evening with the view of a further discussion taking place on the subject which he introduced to us at a former meeting, and the reading of the paper on which subject, has given us much pleasure and a great deal of information; and also in the hope that other officers may make suggestions on the subject, so that we may all of us be able to form opinions as to the best system for preventing collisions at sea at night. I think it would be desirable, if Captain Heathcote would be good enough, to give a short statement of what took place the other evening.

[Captain HEATHCOTE then made a short statement of the principle of the improved arrangement of the lights of steam-vessels by him proposed and described in the paper read on the 16th April.]

Captain HEATHCOTE: I should now like to make a few remarks upon the question of *the height of the bright light*, because, when the paper was read, some gentlemen expressed an opinion that it was not necessary to have any fixed proportion between the height of that light and the distance of the side lights in front of it. As I understand it, this is an essential part of the arrangement. I would explain that it is so in this manner:—Supposing that the height of the bright light is fixed at the proportion which I at present consider best, then A and B in the accompanying diagram will represent in elevation the positions of the bright and the green lights respectively of a vessel, which is beam on to the observer, that is, steering at right angles to the line of bearing, because the green light B is seen as far to the right of the bright light A as that light is above the level of the green light. And this is irrespective of the size of the ship: it is a matter of proportion only. And if any other proportion be adopted for the height of the mast-head light, so long as that proportion is fixed, and known, and universal, the same object is attained. Thus, if it were thought better, and perhaps it might be better, that the height should be only half that above



mentioned, then C would be the position of the bright light in relation to the green light B, when the vessel seen is beam on. On the other hand, if the height fixed be double what I first proposed, then D and B would be relative positions of the lights, under the same conditions. Whatever the proportion be, if it be fixed and universal, as I have said before, the lights whenever seen will tell an unerring tale; but if there be no fixed proportion for the height of the bright light, then any indication, except that of the four points on the bows, must be liable to some degree of misinterpretation. I admit that some idea, and perhaps a valuable one, would still be given of the course steered by the vessel seen; and thus, be the height of the mast-head light what it may, the proposed arrangement would be an improvement on the present absence of arrangement, but that a misinterpretation to some extent would be involved is very clear; thus, a ship carrying her lights in about the proportion represented by C and B, when beam on, will show them in about the relative positions of D and B (for we are dealing with proportion, not with height or size), when steering a course about five points instead of eight points from the line of bearing; and thus if one ship carries her lights in this C B proportion, and another in the D B proportion, although the fact of the green light being observed to the right of the bright light is a sure indication that the ship is steering *more* than 4 points from the line of bearing, it cannot be known whether her course is 5, 8, or 9 points, from the direction in which she is seen. But this *can* be known if the proportion of height is fixed and universal, and this is my reason for urging this point as an important one in the system proposed.

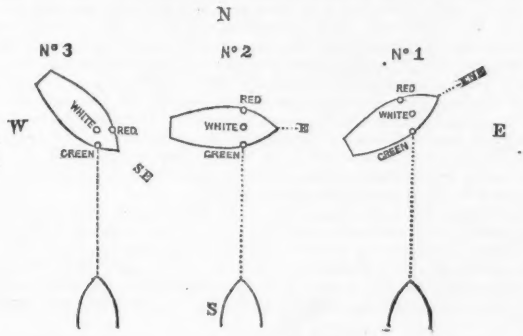
W. STIRLING LACON, Esq.: I was present at the last meeting, and I found that very early we departed from what I considered the main object of the paper, which was to determine in what position the lights of steamers should be carried. A gallant naval officer went into a question which I think was rather foreign to the subject, namely portable lights. I believe those portable lights are very valuable as accessory to fixed lights. But I think it is only justice to Captain Heathcote that we should

first of all express an opinion upon the system proposed by him, and then go into the wider subject. There was also another gallant officer who said he was coming up the channel lately, and that he noticed vessels carrying no lights at all. That is an important point also; but it ought not to interfere with the subject of this paper, especially as I believe that such questions will very soon occupy the attention of the country, and that those persons who systematically break the law shall be made "to answer to the law." In order that I may not depart from the question myself, and that I may not unnecessarily occupy your time, I will, if you will allow me, read from some notes which I have prepared—after a careful perusal of Captain Heathcote's paper, which he sent to me some days ago, because I think upon such a momentous subject as this, no one should put forward anything that is not well and properly considered. Perhaps I may be repeating to a certain extent what you have just heard explained by Captain Heathcote, but I will be very short.

"At the last meeting a good deal was said, and nothing agreed to, as to the height of the *bright or white light*, and its value, as regards the system proposed by Captain Heathcote. It is fortunate that the value of the system, as proposed, does not, said Captain Heathcote, depend upon the height of that light. That light, although it may come into operation in Captain Heathcote's system, has been adopted for a totally distinct purpose. It is a light ordered by Act of Parliament to be carried at the foremast-head to distinguish steamers from sailing vessels, 'so 'fixed as to throw an uniform and unbroken light over an arc of twenty points of the 'compass, so fixed as to throw the light ten points on each side of the ship,' &c., &c. It is, in practice, carried below the foreyard to keep it clear of ropes, and before the sail when the square foresail is set; these positions are probably, under all the circumstances, the best. But if it was carried so low as Captain Heathcote prefers, it would have the broader portions of the head-sails, when set, interfering between it and the horizon, and if so low as to form the right angle triangle, as depicted in the diagram, you will, in all probability, lose it altogether when the head-sails are set, for it will be interfered with by the fore stay-sail, and when the square fore-sail is set it would be obscured altogether.

"What Captain Heathcote has done is to direct attention to the fact that, although by law, certain lights are ordered to be carried, namely, a green light on the starboard side and a red light on the port side; yet, as no directions are given as to the exact position of those lights, whether they are to be carried before or abaft the beam, it is impossible to tell what is the direction of an approaching ship's head, and what course she is steering.

"If, for instance, in a dark night, your own position being *South*, a ship (No. 1),



with *her green light fixed two points abaft the beam*, is seen with her green light and bright light in one, her head will be E.N.E. If another ship (No. 2), seen imme-

diately afterwards with *her green light fixed abeam or abreast of the bright light*, is seen with her green light and bright light in one, her head will be E. And if a third ship (No. 3), seen immediately afterwards with *her green light fixed four points before the beam, or four points from the bow*, is seen with her green light and bright light in one, her head will be S.E., and each ship is carrying her lights according to law.

"This, then, is the fact, that in consequence of the Act of Parliament making no provision as to the position in which the green and the red lights respectively shall be carried, you may have either of them on with the bright light, and you cannot tell within eight or ten points which way the ship's head is, and which way she is steering. Captain Heathcote proposes to remedy this by making all steamers carry their lights *in a fixed relative position*, and for his suggestion I think he deserves the thanks of the country and the shipping interest.

"He proposes that the red and green lights should be carried (*in all cases*) four points before the beam or four points from the bow; then, he says, if a ship is seen with her green light and bright light in one, you will know the direction of her head, and that if she opens out her green light to the left of the bright light, you will know that she is following what is considered by some as the "rule of the road" by porting her helm, and you will soon see her red light; *or, that as regards yourself*, you are crossing her bow, and that great caution is necessary till you open out her red light. On the other hand, if the green light opens to the right of the bright light, you know that the ship is either putting her helm to starboard, or that you are passing astern of her; but Admiral Collinson, who was in the chair at the last meeting, and who is a practical man, and whose opinion is worthy of respect, says, that if you place the red and green lights so much before the foremast, he sees great difficulty in trimming them when you get into a sea, for the *rule* must be applicable to all steamers of whatever construction.

"Might not the same object be attained, therefore, by *fixing* the red and green lights abeam or abreast of the foremast and the bright light, or two points before the beam, although the position may not be so desirable as that suggested by Captain Heathcote. I am aware that it was said by Mr. Harper at the last meeting that by placing the three lights in one vertical plane there might be a difficulty, but would the difficulty be as great as that pointed out by Admiral Collinson as attending the former plan?

"Would it not be possible with the *lights abreast* to ascertain the position of the approaching ship's head, and what she is doing, and to regulate your action accordingly?

"If the approaching ship, with her lights in one vertical plane, is steering the same course as No. 3, she (the approaching ship) will have *hers* considerably open. If she opens them more, you will know that she is following what is considered by some as the rule of the road, by porting her helm, and you will soon see her red light, or, *as regards yourself*, that you are crossing her bow, and that great caution is necessary till you open out her red light. On the other hand, if the lights close, you will know that she is either putting her helm to starboard, or you will be passing astern of her, and when the lights are in one she will be broadside on. As I said before, I am free to admit that the angle proposed by Captain Heathcote is the most desirable, and ought to be adopted, could all the objections, such as the one raised by Admiral Collinson, be got rid of. Whatever may be the future position of the red and green lights, there can be no doubt whatever that *a fixed relative position* for the lights in all steamers is an actual necessity.

"So convinced am I of this, that in the hope of strengthening the hands of Captain Heathcote in his good work, I do not hesitate to express it as my opinion, in which I trust I shall receive the concurrence of the meeting, that, 'there being no provision in the Act of Parliament as to the relative position in which lights on board steam-ships should be carried, it is desirable that the position of the green light on the starboard side, and the red light on the port side should *be fixed* by law.'"

Before I conclude I would make a short remark upon a supposed case of two vessels situated in the position of the "Black Prince" and the "Araxes" mentioned in Captain Heathcote's paper.

The question must not be looked at from the point of view of an intelligent captain of a ship, but from that of a half-hazy, half-sleepy, half-instructed master, who has honestly endeavoured to make himself acquainted with the Admiralty instructions, diagrams, and many hundred clauses of the Merchant Shipping Act.

A is steering north, and sees right ahead the green and bright light of another vessel B. The night is very dark, and the lights only can be seen; *B's green light is well open to the left of the bright light*, and A's captain imagines that B is steering "end on, or nearly end on, so as to involve risk of collision," and that he must put "the helm a-port, so that each may pass on the port side of the other."*

He follows, therefore, what he believes is "*the rule of the road*," and *ports his helm* accordingly.

But B is steering E. or E.S.E., with her coloured lights, perhaps abaft the main-mast, *she is moving rapidly*, and her captain first sees A rather later than when A first saw him, *he has passed a little on A's starboard bow*, and A's lights, namely, a green and a bright light, are nearly a-beam.

He thinks, therefore, he has only to continue his course, and that the ships will pass in safety.

Presently, however, B's captain sees A's red light, and that she is rapidly coming up with and endeavouring to pass a-head of him; A having ported his helm (*the rule of the road and porting the helm* occurs to him also). It is too dark to judge of distance, he puts his helm hard-a-port, but it is too late, and a collision takes place.

H. C. Rothery, Esq.: With your permission, Sir, I would wish to make a few observations upon Captain Heathcote's paper. I regret to have to say anything that would seem to be in disparagement of what has fallen from Captain Heathcote; for no one can have a higher opinion of the ability shown in the paper than I have. There is, however, one point on which I ventured to address a few observations to the meeting on the last occasion, as to the height of the white light with reference to the red and green lights. And although I had not the good fortune to be present when Captain Heathcote began his observations this evening, I came in, I think, before he had addressed himself to that particular point, and nothing that I have heard to-day has induced me to alter the opinion I had previously formed; at the same time, it is probable that Captain Heathcote may be right and I may be wrong. The point in Captain Heathcote's paper that I refer to, I could explain much better with the diagram than without it. I came in when Captain Heathcote was describing this diagram, and the observations that he made, if I recollect rightly, were these: You observe that if this vessel ports her helm, the red light closes in with the white light, if this vessel starboards her helm, the green light opens to the white light. The observations that he made had reference to nothing else but the closing and opening of the red and white lights, or the closing and opening of the green and white lights; it all had reference simply to closing and opening of the lights.

Mr. Lacon: Did he not say, opens to the right and opens to the left?

Mr. Rothery: Quite so. Moreover, Captain Heathcote stated that some vessels might like to carry the white light up high, and others might carry it low. This is, in my opinion, one of the strongest reasons why you cannot have any fixed proportion between the beam of the vessel, or the distance between the two coloured lights and the height of the white light above the deck. If you draw a vertical line passing through the green light, whether the white light be high or whether it be low, it retains the same horizontal distance from the vertical line. I think that Captain Heathcote has given too much importance to the variation of the angle, which a line drawn from either of the coloured lights to the white light makes with a vertical line passing through the white light. Now, I think that angle has nothing to do with it at all. Supposing a vessel had another four points on her bow, the coloured light and white light of the former would be seen vertically, one above the other; now if the vessel put her helm either to port or to starboard, the immediate effect would be to throw the lights out of the vertical to the right or the left. Whether the white light was high or whether it was low would make no differ-

* Vide Art. 13, Steering and Sailing Rules, and Merchant Shipping Act, 1862.

ence, it would be thrown to the right or left of the coloured light. I have here three small tapers, which I think will illustrate what I mean perhaps more clearly than anything else. I will now light and fix these tapers. (The speaker here lighted the three tapers, coloured respectively red, green, and white, and then fixed them on the diagram of a vessel in the positions which would be assigned them by Captain Heathcote.) If the vessel is coming end on toward the Chairman, you would see all the three lights. Supposing, for instance, I am going in this direction, so that I am four points away from the direct line towards the Chairman, then the Chairman would see my green light and my white light. If I port my helm at all, then my white light opens to the left of the coloured light; if I starboard my helm, it opens to the right of it. Whether the white light be high or low appears to me at present to make no difference. The important part of Captain Heathcote's system is whether the white light is to the right or left of the coloured light, and whether the lights are opening or closing. Theoretically, no doubt, it is of importance to know distinctly whether a vessel is two points and a half or three points; but, practically, it does not matter much. It is a matter of much greater importance that you should know which way a vessel is opening her lights—which way her helm is being put, than it is that you should know whether she is two points and a half or three points. I thought there was a great deal in the remark made by Mr. Lacon, that there is only one place in a ship, namely, the fore-masthead, where you can generally hang the white light. And inasmuch as the foremasts differ in different vessels, it would be extremely difficult to put the light in such a position that it could be clearly visible, and yet be at some fixed distance, say half the beam, or the whole breadth of the beam, above the deck. Supposing, for instance, a ship shows two points open, you see the white light and the coloured lights open, and the same if she was three points, or only one point; and, no doubt, there might be a difficulty in ascertaining exactly the number of points; but, I do not think you could trust a seaman to determine accurately to one or two points, even if the white light was at a medium fixed height above the deck. All my observations have reference to that particular point. In other respects, I think Captain Heathcote's observations and his system are most admirable; and I do perfectly concur with the gentleman who spoke last, that it is a matter which ought to engage the attention of this Institution, and that they should call upon the Government most urgently to put the coloured lights in some fixed position relatively to the white light. I entirely concur with that gentleman that four points on the bow would be the best position for the coloured lights, for then you would get the two lights in one when you are four points on the bow; and you would much sooner see a change, of course, whether the white light opened to the right or to the left of the coloured light. In small vessels there may be a difficulty in carrying them four points on the bow; that is a question for practical men, but if you could, I should say undoubtedly that the four points' position is the best; under any circumstances, however, I think that Captain Heathcote's system is an immense improvement upon the existing system.

J. A. W. Harper, Esq.: In respect to that question of the white light above the coloured light, it seems to me that the great point is the nearer the white light is to the coloured light the more distinctly and more clearly every variation in the position of these lights is seen. So that, if you put the white light at a considerable elevation above the coloured lights, the indications to a vessel at a distance will be much less clear, much less distinct than when they are nearly in the same horizontal plane. Supposing they are in the same horizontal plane, a vessel approaching, seeing those two lights in line, the white light a little above the other, knows the course of that vessel to be four points to starboard or port of that line, the least change in the course, when the lights are in that position, is very distinctly seen. It does seem to me that those indications are much less distinct when the white light is at a considerable elevation above the other lights; the white light should perhaps be sufficiently elevated to be seen above the coloured light distinctly and clearly when the vessel is four points on the other's bow, but yet not so high as to make it difficult to discern the delicate differences which are produced by changes of course in the approaching vessel. It seems to me that a difficulty attends Captain Heathcote's system. What

becomes of these lights when the ship's stay or square foresail are set? If I am correct in thinking that the system is more accurate, when the white light is lower, *i. e.*, nearer to the coloured lights, if you keep the coloured lights on the ship itself, the system is almost destroyed when the ship is under sail. I do not know whether that is so. Supposing it to be so, when navigators are looking for indications of the course of an approaching ship, I imagine their view might possibly be so distracted by the lights being obscured by sails that a very serious mischief might follow. Then comes the question, is it not possible to arrange the lights in such a manner that you may secure all these indications without those difficulties. Suppose a jackstay, with an arm to the right and to the left, and a light at the end of each arm, and the white light in the centre, is it not possible to suppose that the lights might be arranged in this way, so as to get over the difficulty I have pointed out?

Mr. ROTHERY: I should like to say one word about what Mr. Harper has said. No doubt it would be most important, if the lights could be as much as possible upon the same horizontal line, because you do see a variation much more rapidly than if the white light is higher. But then, inasmuch as the white light must be placed in the middle of the ship, it would be obstructed very often by sails or by persons moving about, unless you put the whole of them up high, in fact, on a level with the foretopmast-head. And considering that these lights have to be carried, both in fine weather and in rough weather, I would ask what kind of support you could give to your coloured lights in that position, so as to prevent their being blown away. No doubt this point is a very important one if it could be attained; and I should like to hear what Captain Heathcote has to say on the subject.

Captain BURGESS: Admiral Ryder, being unable to attend, has sent a few remarks, which, with your permission, I will read to the meeting:

"SIR, "June 17, 1866.

"I regret very much that I shall not be able to be present at the discussion on Monday. Captain Heathcote's proposal appears to me to be very valuable, and I think the position he advocates, viz., that the side lights should be four points on each bow, measuring from the masthead lights as a centre, is the best, provided the lantern is so fitted as to be easily accessible in bad weather, and so strongly fitted as to be able to resist the blows of seas, seeing that the position is rather exposed.

"A lamp, invented by a Mr. Brown, of Deptford Dockyard, and which has been fitted for binnacles, has the valuable property of heating its own oil—which prevents the necessity of re-trimming for many hours. I believe that lamps of this description, if trimmed with Colza oil, would not require to have their wicks cut more than once in twelve hours, provided the reservoir was slightly raised above the wick, so as to produce an overflow of oil.

"If the side lights can be so fitted as not to require to be disturbed throughout the night, the only objection to the exposed position recommended by Captain Heathcote would be removed. The great advantage of the position proposed by Captain Heathcote, viz., the *side lights four points on each bow*, is, that that position is the middle point between the extremes of danger and safety, viz., between the position in which the ship's head is pointing at you, and that in which her course is parallel to yours. By the two lights being in one in this central position, any variation to the left or right, showing that the angle included between the courses of the two vessels is *changing*, is easily detected at once. Whereas if the side lights were abreast of the mast-head lights, and the ship is first seen in the same position as above, any change in the angle included between the two courses will not be so easily detected, as it is much easier to detect changes in a small angle than in a large angle.

"Whether both ships are *under weigh*, or one is at anchor and the other under weigh, no conclusion could be drawn by the captain of the ship at anchor in the one case, or by either of the captains in the other case (even if Captain Heathcote's proposal was enforced by law) that the other ship *had put her helm either one way or the other*, merely because the green or red light was seen opening out to the left or right of the masthead light—but if the relative positions of the side-lights and mast-head lights are regulated by law, the captain of one ship, on perceiving the approach

of another ship, would be guided to a much safer conclusion as to whether there is any risk of a collision, and as to what steps ought to be taken to prevent such an accident than if, as at present, the side lights may be anywhere.

"Yours faithfully,

"A. P. RYDER."

Commander COLOMB, R.N.: As I was one of the unfortunate culprits who went a little further than he ought to have gone on the last occasion, I must endeavour not to go so far this time. Several remarks have been made by different speakers to-night, which I think call for a little further notice. It is quite possible that one might make a very slight amount of confusion—confusion worse confounded!—an unpractised speaker very often does that. However, I shall endeavour to address myself to two or three points, which I think want to be made a little clearer. First of all, I would take Admiral Collinson's objection to Captain Heathcote's proposal. He said he thought that there would be a difficulty in trimming the lights if they were placed in a fixed position so far forward. Now, on board a great many of the larger class of men-of-war, the lights never appear on deck at all; they are trimmed between decks, in a small place built out through the ship's side, where the lanterns are placed with very strong plate-glass outside. You can carry that system to any extent in smaller vessels, because there is no reason why there should not be a communication between the deck below and the inside of the glazed niche, which will show outside the ship, so that a lamp may be taken inside this covered passage, trimmed between decks and replaced. It need never appear on deck at all; it need never appear in the air; so that as far as that goes, I do not see any objection to the admirable proposition of Captain Heathcote. Now, there have been a great many questions raised, if I understand it aright, as to the necessity or non-necessity of a relative proportion between the height of the mast-head light and the breadth of the ship, or rather the breadth between the two lights. It has been said that whatever that height be, let it vary in ships, that still you will ascertain alterations of helm by the closing or the opening of the green or red lights from the vertical line of the white light. Now if you only wanted to ascertain changes of helm, that of course would attain your purpose. But that is not all you want to ascertain. You want to ascertain, on first sighting a ship, without any change of her helm whatever, what her course is: because the very moment you see a ship at sea, it is desirable you should at once be able to make up your mind what your own course should be. The great difficulty you have on meeting a ship at sea, is to ascertain at once how she is steering, so as to understand what lies before you, and to see what your proper course should be—whether to follow the rule of the road, as they call it, or go contrary to that rule of the road, which is often the rule of safety. Unless you have a fixed inclination of the lights, for every difference of course of the ship you are approaching, from the line of bearing—unless that inclination be fixed in every ship, how is a seaman to form any judgment whatever as to the course the ship is steering? We will say, you have a ship a-beam. You know you are a-beam of her, because of a certain angle formed by the line joining the lights with the horizon. You see a certain distance between the lights. That ship may be much further off or she may be much smaller, but the two lines which join the lights form the same angle with the horizon; and whether the line be here or there, you know that the ship is steering the same course—you know you are a-beam of her. That is the point that Captain Heathcote wants to establish first of all. Now, another point was brought forward. Mr. Lacon said there would be this difficulty, if the lights were brought sufficiently low down to make the height of the light a good proportion with the beam of the ship, the bright light would be covered by the head-sails. I should imagine that when the head-sails were set, we do not care so much whether she is a steamer, because she is governed by the wind; and if you do not see the white light at all, you understand that ship to be governed by the wind. Whether she is a steamer or a sailing-vessel can make very little matter to you, you can ascertain her course by what the wind is. I had prepared some remarks opening up the whole question, but at this hour of the evening, and having very vividly before my eyes what has passed, I think perhaps it would not be advisable to go any further. The question

is a very much larger one than the meeting is at present aware of. It is very well for us to lay down regulations as to the position of the lights, but the regulations as to the nature of the lights is only in a slight degree attended to. It is evaded by way of cheapness in the smaller class ships, and in some of the larger, to a very extraordinary extent. There are very few lights—mast-head and side lights, ordinarily supplied to ships which fulfil the regulations. There are very few side lights which show to two points aft the beam; there are very few mast-head lights which show to more than fifteen points of the compass. At present we cannot get the regulations obeyed, and we must first turn to the rule of having the law obeyed, and then we can go on making our laws with the certainty that they will continue to be obeyed. The question is such a large one, that though it is late in the session, I should be very much disposed, if the Council wished it, to draw up a short paper going a little further into the way in which the law is evaded, the construction of lights, and the general state of the case as regards those lights. There are one or two speakers beside me who would wish to branch out a little; and I think the feeling of the meeting is that, whatever the minor details of Captain Heathcote's plan might be, the plan itself is so admirable that it strikes you at once as being the thing that should be adopted and carried out. To my mind there can be no dissension about the matter. It seems quite certain that some plan of that sort regulating the position of the bow lights as regards the mast-head light should be adopted.

Mr. HARPER: That strikes me as a most startling proposition, that a steamer under sail is governed by the wind.

Captain COLOMB: So far as you are concerned only, on approaching her and making out her course.

Mr. HARPER: There is considerable risk of interference by the sails of a steamship with the accurate defined settled system of Captain Heathcote. Is it true that a steamer under sail is governed by the wind? If it is not, it does seem to me that the system proposed by Captain Heathcote would be materially affected on occasions when sails were used by a steamer. It seems to me to be true that the system of Captain Heathcote would be much more accurate in proportion as you get the white light lower down, and the angle which it forms with the coloured light more obtuse. It may be important to put the white light at any height contemplated by Captain Heathcote. But it strikes me it is dangerous in proportion as navigators have to depend upon accurate observations, and upon the view they conceive of the course of vessels by the indications of the lights, if those indications are, upon a particular occasion, obscured or done away with by the sails. If it is true that a steamer under sail is governed by her sails, of course you have independent indications which are quite different. It does seem to me that that question has not exactly been touched, namely, that there may be a chance of that excellent proposition of Captain Heathcote's being practically interfered with. Supposing that to be admitted, it is quite possible to consider whether the principles laid down by Captain Heathcote cannot be by some little practical alterations made independent of these difficulties.

Captain HEATHCOTE: What Mr. Harper very much fears is that the indications might be false. I would remark, that where there is no bright light seen, there will be no indications. Where a green or red light only is seen, the vessel would be supposed to be a sailing ship, and treated accordingly.

Mr. RIDGWAY: I would remark that while everything has been said with reference to the position of the lights, nothing has been said about the duties of the officers on board ship and of the men who navigate the ship, a very material point. The question of collisions at sea is one of considerable importance. I, unfortunately, on one occasion put twenty-nine persons on board a ship. They got as far as the Downs. Either a steamer ran foul of the ship or the ship ran foul of the steamer. Being called upon to pay money to the people who embarked, I inquired "Who is to blame?" It proved, on investigation before the Trinity House, that the ship had been the cause of the accident, owing to the negligence of her officers and men, so I paid no money. I think that many collisions take place at sea, not from the wrong position of the lights, but from the inattention of the persons on board. Frequently the owners of the ship appoint to the command inefficient individuals. A

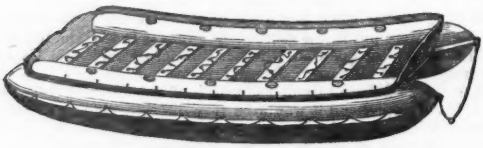
case occurred a few days ago where the pilot of a ship found that the officers of the ship were drunk before he left the ship.

Captain HENRY D. GRANT, R.N.: I only wish to say that Captain Heathcote's system is one that merits the full approbation of every seaman. As having had command during the last four years of cruizers in the most dangerous waters on the coast of America and New York, the difficulty I practically found was in knowing exactly the position of the lights. Very often I have known, particularly in French vessels, that the lights have been placed in steamers right abaft the mizen mast. In some they are aft the bridge. So great is the uncertainty as to the position of the lights, that very often, when I have seen a vessel, the first question that has come into my mind has been, "Where is that vessel's light placed?" Because it makes a very material difference whether they are placed on the bow or aft. One vessel I commanded was a very small gunboat; and I think I may be allowed to be a judge as to whether there was any danger in placing those lights forward. During that time we passed through three hurricanes, and we never had the lights once washed out or damaged in the slightest degree. The place was a box built into the bulwarks forward, with strong plate glass. Once only we had a plate glass smashed, but even then the light was uninjured. But I do think it is a question of very great importance whether we could not have better lights. The lights of Mr. Brown have struck me as being the best adapted for our purpose, especially those for binnacles. With regard to the observations about vessels being under sail, I do not think that is of so very much importance; because if we are out in the broad ocean, and we see a vessel with her steamer lights, whether she is under sail or under steam, we are to treat her as a steamer. But the importance of Captain Heathcote's system is in close waters, such as running up a river, when the commander of any steam vessel would be highly culpable that carried sail. We want then to be in the position to do any possible thing under steam, and no vessel can do that if she is carrying sail. With regard to another question that has been mooted, the responsibility of the officers, I must say that when I have seen mates of merchant ships keeping watch and watch, I have thought it was a very hard matter for them to be able to look after lights, or to have their minds clear in very difficult water.

The CHAIRMAN: However we may differ as to some of the details of this subject, I think we must all feel extremely obliged to Captain Heathcote for the clear and lucid way in which he has brought this subject before us; and I must add, the very efficient system which he has brought forward. We are also very much obliged to the gentlemen who have favoured us with their opinions and criticisms on the subject, because I feel convinced that the more a subject of this sort is investigated and criticised, the more nearly we shall arrive at the truth, and add to the efficiency of the service. There are various points involved. I do not know whether it is necessary to go into them all. For myself I should prefer naturally, the position that Captain Heathcote proposes for these lights; but I see some practical reasons in the case of the mast-head light against that. The only place that I can see for a mast-head light to be constantly in view at all times, in all cases, and in all positions, for it must be always that, is at the mast-head. I cannot see that it would do anywhere lower down. If I place it lower down, nearly on the level with the side lights, as was proposed by one gentleman, there are so many objects in the centre of the ship, that would interfere, right or left of the bow, with the sight of that light. Moreover, a steamer, though under steam, may have a sail set; may sometimes set her jib, sometimes set her foresail; and we know that any light low down on the foremast, would thus be invisible. It is only above the fore-yard that a light on the foremast can be seen permanently, some put it on the forestay; but it must be decidedly above the line of the foresail or before it. Now, an objection was taken to the position of the bow lights being, as Captain Heathcote proposes, a certain distance before the line of the foremast. For myself I see no objection to that. One of the gentlemen who has favoured us with his opinions, as having commanded a small vessel, has given us a practical case in point. I can myself mention that when I commanded a line-of-battle ship in 1854, I was one of the first who placed the bow lights in the position described, on the middle deck well forward, and they stood in every case of bad weather. They were trimmed from the main-deck with

all the advantages that we have heard mentioned to-night. I believe that the same thing can be done with care in small vessels. I do not want to go into the duty of officers, seeing that their lights are trimmed; for if there is one thing in which I have found officers and men equally ignorant and equally careless, I must say, it is in the trimming and the care of lights. They do not know the conditions under which oil is burned. Many of them shut up a lamp, and think it is to burn without air. Having had the superintendence of an Admiralty dockyard, I can speak from long experience upon that point. I have never seen grosser ignorance on the part of officers and men than upon that point. But I do not see what objection there is to have the deck lights in the position Captain Heathcote suggests, before the foremast. I think we could always carry them there, taking care to provide them with fresh air, and to protect them from the stroke of the sea. I can see a great advantage also in knowing exactly when that angle of 45° comes on. We should lose that entirely, if the lights were put in the same plane; that is to say, the line of the beam of the ship. Then comes the question, whether that actual angle that Captain Heathcote wishes is necessary in all cases. There I conceive there may be a considerable difficulty. Ships are so different; and the length of the foremast differs so much in different ships, that I apprehend it would be very difficult, judging by what I see of the various beam of ships and the various length of foremast—for I always look to the necessity that the light should be above the foreyard—I think it would be very difficult to maintain that angle. But I think we could always maintain that the side lights being before the line of the foremast, when showing in line with the white light, should give that angle of 45°. I think that is a very great principle, and one of very great importance. Another point was started about the lights themselves. There is no doubt that we can very much improve our lights. I heartily wish that the subject could be gone into another evening, for it is somewhat late this evening, and I must tie myself down to the subject before the meeting, and not go into the nature of ships' lights. The subject before us is an improved system of lights as to position, and that is what I wish to keep to. But I may remark that we may improve our lights very much. But I really think there is something more for us to do; all of us who are in command of men must really try and improve their common sense. I have seen lamps of the very best construction that the Admiralty could put into ships, and when I have gone round the decks, they were completely filled with black. They might almost have been green or red lights, so obscured was the light, and yet those gentlemen who had the charge of them thought they were doing their duty. Therefore, while we are talking about lights, we must see that those who have charge of them must know how to treat these lights. I think that a Captain ought not to be above seeing that everything is done properly on board his ship. He is as much bound to see that the lamps are clean as that her head is steered correctly. We may improve our ships' lamps very much, but we must do something further than that; I do not know a better way of doing it than by discussing the subject before a meeting like this. We shall all learn something. I have learned something at the lectures, on both this and the previous evening, from Captain Heathcote, and from the gentlemen who have spoken. And, once for all, I must say we are very much obliged to these gentlemen for the information they had given us.

PATENT IMPROVED LIFE RAFT INVENTED AND EXHIBITED BY J. W. HURST, M.M.



This raft is constructed of two light iron pontoons, parallel and secured to each other by cross iron bars between them. Each pontoon is protected on the outside by waterproof sacking stuffed with cork, which not only acts as a fender, but of course gives additional buoyancy. The deck is placed over the bars and secured to angle-irons attached to the pontoons; these are built with air-tight compartments; over each compartment is a man-hole where provisions, water, and all other requisites may be stowed with safety. A raft of thirty feet in length would stow and carry sixty people with a supply of provisions and all other requisites. The raft is so constructed that it could be launched from off the boom and deck-houses into the sea in any weather in safety without the use of tackle, when ship's boats are found useless; or it could be carried outside, forming part of the bulwark, and dropped into the sea at a moment's warning by merely withdrawing two pins. It can be rowed and sailed with the greatest convenience; the people can be secured on the deck of the raft by life-lines rove through eye-bolts in the deck, the lines passing over their legs near the waists; besides these, additional life-lines would be stretched across the deck at suitable distances. It will be seen from the construction of the raft, that it is almost impossible for it to be upset. This kind of raft could be employed when lifeboats could not reach a wreck. It could also be employed in landing troops on a shallow coast or in shallow-water rivers.

LECTURE.

Friday, 4th May, 1866.

MAJOR-GENERAL VINCENT EYRE, C.B., in the Chair.

"THE BRITISH SOLDIER IN INDIA."

By Dr. MOUAT, Surgeon-Major H.M. Bengal Army, Inspector-General of Prisons, Bengal, F.R.C.S., &c.

PART I.

The CHAIRMAN: Having been invited to preside on this occasion, I do so with great pleasure, since it affords me the opportunity of introducing my old and esteemed friend Dr. Mouat, who has come to lecture to us on a subject of the very highest importance in connection with the objects of this Institution; namely, "The British Soldier in India."

Dr. Mouat must, doubtless, be already familiar by name and reputation to many here present, as one of the most distinguished members of the Indian Medical Service. During his 25 years of active life in India he has filled several important posts under Government, and has zealously availed himself of the ample opportunities he possessed of acquainting himself with the actual state of the British soldier in the various localities where he is stationed; and, in 1858, he published in Calcutta the result of his observations in an interesting pamphlet, containing many admirable suggestions for improving the moral and sanitary condition of our soldiers in India, which may probably have conveyed some useful and timely hints to the Commission then about to sit in England for investigating these matters.

Since that period, however, vast changes have taken place in our Eastern Empire. The old East India Company's rule has passed away; their European Regiments have been amalgamated with the Royal Army of Great Britain; the total British Force in India has been more than doubled in strength; and, although much has been already done to rectify old errors and to improve the condition of our Barrack life in India, it is generally admitted that very much more still remains to be effected; and I am sure that Dr. Mouat (whom I now call upon to

commence his lecture,) will have much to communicate that can hardly fail, not only to interest and instruct those now present, but also to impress beneficially those public officials who possess the power and influence through which alone his suggestions can be carried into practical effect.

Dr. MOUAT: General Eyre, Ladies, and Gentlemen, I do not think I ought to feel indebted to my friend General Eyre for raising your expectations to an extent that I am afraid I shall disappoint. However, General Eyre has told you—and I think told you correctly—that there are few subjects connected with the British soldier that at the present moment are of greater interest and importance, than everything relating to the European force in India. Not only is a large portion of the British army—probably not less than from 50,000 to 60,000 men—likely to be permanently employed in that country, but the maintenance of our empire in India depends upon the gallantry and upon the good and soldierly conduct of this army. There can be no doubt whatever that India is at present a military empire, so far as we are concerned, and that it must continue to be so for many years to come. It is essentially an empire of the sword, and not an empire of opinion. It is quite true, as the late Sir Henry Lawrence, one of the best soldiers the Indian army ever produced, said in an article which is contained in an early number of the "Calcutta Review," that "one good magistrate may be better than a regiment; one sound law better than a brigade;" and that the administration of wise laws may effect works that armies would fail to accomplish; but unless the British soldier were there to support the magistrate, and to aid him in administering those laws, I fear that our hold upon India would be small indeed. Those who ever laboured under a contrary belief must have been satisfied from the results of the Sepoy Mutiny of 1857, that our hold upon the country depends rather upon our military strength than upon the affection of the people for our Government, just and equitable as I believe our rule for the most part to have been.

In proof of the interest and importance of the subject, may I ask you to cast your eyes upon the skeleton map before you for a few moments, and you will at a glance perceive the vast responsibility that falls upon the British army in the performance of its duties in connection with India. Upon this map all that is coloured red in its various parts belongs to the British Government. There are a few patches here and there coloured differently that are at present either tributary, or remotely dependent, or, in some instances, entirely independent of that Government—to their great misfortune, for if, in my humble judgment, there be any event in their past and recent history that has been more valuable to any portion of that country than another, I hold it to be that its rule has been assumed by the British Government. Take, for example, the important province that was last added by one of the greatest rulers India ever saw, the province of Oude—the annexation of which province was supposed, in a great measure, to have led to the mutiny; a supposition I hold to be incorrect. Contrast the condition of that fine province, now that it has been for a very short time subject to British rule, with the state in which it was only a few short

years since, as described by Sir William Sleeman from personal observation; and I think it is impossible for any sensible and unprejudiced man to deny that the greatest benefactor that country ever had was the late Marquis of Dalhousie.

In speaking of the British soldier in India, you will readily understand then how difficult it is for any one to treat the subject so as to condense a tithe of the information which has to be communicated regarding it, within the short space of an hour. You will perceive that the English possessions in Hindustan are bordered on nearly three sides by vast mountain ridges, rising in some places to a height of some four or five miles above the surface of the earth—some of them the highest mountains in the world. Fortunately for us, for reasons connected with the immediate subject of this lecture, which I shall presently refer to, there are likewise lower mountain ranges, intersecting the country in every direction. In addition to these, it has vast alluvial plains, all of which possess peculiar characteristics in relation to the health of the soldier and of the Europeans generally, who reside in them. The delta of the great rivers of Bengal, in the low lying plains of which is supposed to have originated that terrible disease that has more than once spread over Asia and Europe, and is even now threatening us with another invasion, is one of the most extended and important of those plains. Again, if you follow my pointer you will see a sea-board, bounding both sides of the Bay of Bengal, extending Southward on its Eastern side to Cape Comorin and running up again to the North with a very short interval to the province of Scinde, which was added to the British Possessions a few years since by one of the greatest English Soldiers who ever served in India—the late Sir Charles Napier. The whole of the vast extent of territory which I point out, is under British rule. I believe the mountain ridges to measure some 4,500 miles in length; the Coast line to comprise 3 or 4,000 more; and no less than 1,500,000 square miles of inhabited territory to depend upon the British Soldier for the allegiance of their populations to the British Crown. India is peopled by different races, not numbering less than 150,000,000, so distinct from each other, that it would be as correct in speaking of any portion of Europe, to confound the Englishman with the Spaniard, or with the inhabitant of Southern Italy, as it would be to speak of the inhabitants of any given portion of Hindustan, as identical with the inhabitants of any other portion.—There is a much wider difference between the Bengali and the Beloochee, the Mugh and the Mahratta, the Santhal and the Seikh, than there is between any two nations of Europe.

Fortunately for us, the lower and more unhealthy provinces in every direction are inhabited by the least warlike people in the country. They are generally more or less timid races, who are easily held in subjection, do not possess the means, and are destitute of the qualities likely to prove the prowess of the British Soldier in the field. Hence, in a strategical point of view, for the maintenance of the rule of the British Government in India, it is not necessary to station large numbers of British Soldiers in those climates which are most injurious to their health. I will not say more upon this point, because the mili-

tary defence with special reference to the topography of Hindustan, would alone occupy more than the time allotted to a single lecture. I admit freely, that the teeming population of India is chiefly kept in order by the mild and beneficent rule of the British Government; for I believe that Government to be in every sense a paternal, and so far, a model Government, and I know, from long residence in the country, that it strives to do the duty assigned to it, in the manner best calculated to secure the contentment and happiness of the peoples committed to its charge. Among them are, however, a considerable number of warlike and some fanatical tribes, and there is a Mahommedan population, probably numbering not less than 30,000,000 souls, who from the very nature of their religious tenets, cannot be well affected towards a Christian Government, however just and equitable that Government may be towards them. It is foreign to my purpose to enter further into this question, and I only thus briefly refer to it to show how onerous is the duty of, and how great are the interests confided to, the British troops serving in India.

Now, with regard to the British army in India, you will all remember, or most of you probably will remember, that in the year 1859 a Royal Commission was appointed to investigate the condition of that army. After labouring for three or four years, it produced the mass of evidence which is contained in the two thick folio volumes now on the table—one of the most valuable and exhaustive documents ever published on any subject. It has been my good fortune, for I hold it to be so, being connected so intimately as I am with India, to have had access to, and to have studied carefully the contents of this storehouse of facts. I shall not, however, alarm you by opening these volumes, or by attempting to communicate any portion of their details to you. The mere bulk of the volumes is quite enough to repel you from any further acquaintance with them, beyond a statement of the chief revelations which they contain, and which it is my duty today to prove to be no longer a true picture of the British Army in India. At the time this report was published, it presented a very gloomy picture indeed, and would lead one fairly to infer—for I must confess that, from the data which at that time had been accumulated, no other inference was possible—that there was terrible mortality, and a distressing amount of preventible sickness among the English Soldiery in India—that their lives were a constant struggle with idleness and ennui—their existence one of perpetual purgatory in all its relations—that they had no fit places to live in—that the various stations in which they were condemned to pass the best portions of their lives, were so undrained and unhealthy, so wanting in all the conditions of health, as to be better fitted to destroy than to preserve the soldier. The mortality was said to be—and no doubt it was true of the period embraced in the report—no less than 69 per 1,000. That was a very startling fact, and would alone represent a vast amount of misery inflicted on the English soldier by service in that country. In addition to the 69 per 1,000 who were destroyed, there was likewise a large percentage whose health was permanently ruined, and who were sent from India to end their days in poverty and misery at home, for

poverty and misery are unhappily the inevitable end of the career of most sick and worn out soldiers.

Now, although this was all correct at the time the report was written, a great change was even then being effected in the condition and management of the European Soldiers in India.

We live in an age in which a large amount of sensation appears to be necessary to direct and rivet public attention to any particular subject. A railway for instance may be mismanaged to any extent, and people be subjected to constant avoidable risk from such mismanagement, but until it kills a bishop or maims a Prince of the Blood, or until some shocking catastrophe startles the public from its repose, little notice is taken of railway misrule with a view to its remedy. So it has been with regard to the army. To my certain knowledge, ever since I have been in the service, and from records to which I have had access for periods long anterior, the various matters that are contained in the report of the Royal Commission have been recorded as earnestly as it was possible for men to state them, by my predecessors, and by my contemporaries, both in Her Majesty's and in the Indian Medical Services. There is scarcely a single recommendation contained in this report that has not been urged in some form, over and over again. But you will ask me fairly, why, attention having been drawn to the facts, remedies were not applied to diminish or remove the evils? The fact was, even in England itself, so long had Europe been at peace, and so little attention was paid to these matters, that, until the Crimean war occurred, and the whole nation was startled by the revelations that then took place, of the great sickness, lamentable mortality, and heartrending hardships to which the soldier was subjected, public attention was not so forcibly directed to the matter as to lead the rulers of the nation to devote the amount of attention that has since been paid, with the happiest results, to every question connected with the moral and material welfare of the soldier, whether in India or in England.

It is also a singular fact, which has been very long known, that the actual destruction of life from war either in battles or in sieges, or in the purely military contingencies to which the soldier is liable, are infinitely less in any campaign that has ever occurred, than from the other agencies which assist in his destruction. For example, not to go back to earlier wars, of which the statistical details are less reliable and accurate than those collected now-a-days, I have placed on the table a report published in Paris a few days ago. It is a statement addressed by Dr. Chenu to the Council of Health of the Army of France, upon the results of the Crimean War as regards the French Troops. From it I have selected,—I am not going to weary you with a dreary array of dry details,—but I have selected a very few figures, to show that, even with all recent inventions and improvements in arms of precision, the other destructive agents banded together against the soldier in the field are infinitely more terrible than those which have hitherto been discovered and used by man. Dr. Chenu has shown that the following were the losses sustained in that short campaign—a campaign brief in duration, yet one on the whole that

reflects much lustre upon the British Arms, although purchased at a lamentable sacrifice of human life. The English army, which appears to have sent, from first to last, rather more than 90,000 men to the field, lost 2,755 men killed in action. There died of wounds or disease, afterwards, no less than 19,427—not far from nine times as many as were destroyed by the enemy—making a total loss of 22,182 men. The French army, again, which sent there, from first to last, some 309,268 men, lost, in killed on the field of battle 10,240 men, while those who subsequently died of wounds or disease numbered no less than 85,375; making a total loss of 95,615 men;—a very dear price, indeed, at which to purchase the continuance of such an Empire as that of Turkey. In addition to this, the losses in the other armies must be brought into the account to estimate the cost in life of that War. The Piedmontese, who were few in number only had 12 killed; but 2,182 of them died from disease or wounds. The unhappy Turks, from 1853 to 1856, had 10,000 men killed, and 25,000 men destroyed in other ways. But the loss of the great aggressor in this war transcends that of all the rest put together. The Russians are supposed to have lost in action, from 1853—1856, 30,000 men, and from disease and the dangers and hardships to which their armies were subjected, not less than 600,000 men. The Russian loss is therefore estimated at 630,000 men by Dr. Chenu. Although not quite positive in regard to these figures, the reporter had reason to believe that the number given was rather under, than over the truth. So that the whole loss in that campaign, which occurred only the other day, and some of those who took part in which are probably among our audience to-day, shows that there were killed in action 53,000 men out of that armed host; and that there died from various causes, including wounds, no less than 731,984 men!

This points then very strongly and significantly to the fact, that there is no need to cross the world to India to discover destructive agencies, against which the soldier has to contend whether in or out of the actual field of battle. It leads one to marvel much, that, while vast sums of money are expended in rifling cannon, in perfecting guns of every sort and description, so little money comparatively is devoted to saving the lives of the soldiers from other agencies, the losses from which are infinitely greater, than any number that arms of precision are capable, or will ever be capable, of destroying.

There is one little fact connected with the Crimean report which it gives me the greatest possible pleasure to mention, because it comes from an unexceptionable source.—It is the tribute borne by our gallant neighbours to the efficiency of the Medical Department of the British army in the Campaign referred to. I have translated a very short passage from Dr. Chenu's work, which is to the following effect:—"I "had finished my work when I had the good fortune to receive a "communication of an analogous work accomplished in London for "the English army. I have translated the numerous tables which it "contains, and I must confess that I have been unable to attain the "astonishing precision of my brethren of the English army. This "precision which could scarcely be attained in the great Hospitals of

"France in time of peace, leads me to suppose the existence of admi-
"rable and almost incredible method and arrangement from the begin-
"ning and during the whole course, of the war in the English field
"and fixed hospitals; and if, as I dare not doubt, the statistics of the
"Medico-Chirurgical Service of the English army are scrupulously
"exact, it must be admitted that our brethren have been more skilful
"and fortunate than we have." This testimony is indorsed by no less a body than the Imperial Institute of France,* which also bears testimony to the success of the British Army Medical Department.

Now, I am somewhat puzzled how to begin the special consideration of the particular subject which it is my purpose to illustrate to-day, particularly as I am horrified to find that no less than half the allotted time has already elapsed. I will ask you briefly then to look "on this picture and on that." In my hand I hold a report that has been printed within the last two months, by order of the House of Commons—the report of the Bengal Sanitary Commission, showing the condition in which the British Army in India is now, as contrasted with the state in which it was when Lord Stanley's report was printed, the ink of which we may, without much metaphor say, is barely dry—for only three short years have elapsed since it was published in 1863. Regarding the mortality of 69 per thousand recorded by the Commission, with no less a man than Lord Stanley at its head, a hope was expressed that by the various sanitary measures and improvements of different kinds recommended by them, the death rate of the British Soldier in India might, at least, be reduced to that of Her Majesty's Guards in London at the time the first Commission sat, viz., 20·4 per thousand. They hoped that by improved sanitary arrangements thus much might be accomplished, and that, ultimately, a still greater saving of life might be attained. Now this report of the Bengal Sanitary Commission, written by Mr. John Strachey of the Civil Service—and I have the greatest pleasure in bearing testimony to its excellence and the ability exhibited in it, the more especially as it verifies the statement made in the beginning of my lecture—this report I say, shows that the mortality of the army in India, at the present moment, is already reduced to the standard that Lord Stanley's Committee believed to be attainable by the introduction of measures that would take some time to bear fruit. The death rate at the present moment is as small as was that of the Guards in London at the time the first inquiry took place, after the Crimean War. To have descended from 69 to 20 per thousand is a vast jump, and Mr. Strachey has shown, by the facts and figures contained in his record, how this has been done. It has not been by Sanitary Commissions, or by any other non-professional body, that this improved state has come to pass.

* In the memorandum of the French Institute, stating the grounds for awarding the statistical prize of the year to Dr. Chenu, the proportional difference between the French and English mortality is stated to be not so great as the figures seem to indicate, inasmuch as the English returns contained only the mortality in the East, and did not account for those who subsequently died of their wounds in England, while in the French statement every wounded man was traced to his cure or death, wherever they occurred. The reporters go on to say: "Il faut néanmoins réconnaître que le Service Médical Anglais a eu le plus de succès."—F. J. M.

The moment public attention was strongly directed to the matter, a multitude of circumstances which had repeatedly been brought to notice, and had been as often overlooked or disregarded, were carefully attended to. When the medical officer was listened to, and his counsels followed, the amendment began. It commenced before the report of the Royal Commission was written, it continued during the progress of the enquiry, and it anticipated the institution of Sanitary Commissions. The state of the British Army, at the time the report of 1863 was published, was very different from the statement contained in the report itself; and, at the present moment, it is vastly better than anything that could have been expected in so short a time. The credit of this, seems to me fairly to belong to the Medical Department of the army, whose recommendations, when carried into effect, have been followed by benefits which medical officers of experience predicated long since, and which are the strict logical results of the practical application of the doctrines of medical science.*

While speaking, however, of these improvements it is necessary to bear in mind the simple circumstance to which much of the amendment is due, and which needed little knowledge of science to accomplish. Sir Charles Napier said some years ago, in one of those quaint and forcible utterances he was in the habit of using, that climate was held responsible for a good deal that climate deserved no blame for, that gin and overcrowding were the real destroyers of the soldiery. It was so in reality. As respects overcrowding, we need not travel so far as India to witness its ill effects. If you cram two or three people into the space that one only ought to and can occupy with safety, you produce not only a state of atmosphere that conduces to disease, but you produce disease itself. One of the most remarkable cases of the kind that I know of is mentioned by Dr. Tardieu, in his "Dictionaire d'Hygiène Publique." He states that from the year 1843 to 1847, whenever King Louis Philippe went to St. Cloud, the number of soldiers who were attacked by and died from virulent typhoid fever was very considerable; that a disastrous epidemic broke out on every occasion eight days after the arrival of the King; but as soon as His Majesty left St. Cloud, and returned to Paris, the fever disappeared, and the troops became healthy. How was this produced? The condition of the soldier was the same—his food the same—his clothing the same—his duty the same, except that there might have been more pomp and parade when the King was present, than when he was absent; but beyond that, he was not exposed to any of the vicissitudes of war which could account for this unusual sickness and mortality.

* In the Bengal Presidency in 1864, of the 54 stations in which there were English soldiers, the mortality of 41 was below 20 per 1,000; in 12 it was under 10 per 1,000; and at 7 only did it exceed 25 per 1,000.

In France the military mortality is 10·8 per 1,000 for officers, and 22·3 for men, giving a mean death rate of 19 per 1,000, or one per cent. below the present Bengal rate.

In the West Indies French soldiers die at the rate of 75 per 1,000; in Algeria of 70 per 1,000; and when formerly employed in Egypt their loss was 69 per 1,000.—F. J. M.

What then was the cause? It was this: the garrison contained 400 or 500 men for whom there was ample space in the barracks when the King was absent, but when the King was present, 1,200 men were packed into the same space. They were overcrowded in fact, and began to sicken and die rapidly, as they do everywhere in similar circumstances. The same thing occurred in India; and the moment more room was given to the soldiers, and they were not crowded into a space which rendered the barracks pestilential, other conditions remaining unchanged, they immediately began to improve in health. I could give you hundreds of examples of that sort if it were necessary. I will mention one. There is a station near Calcutta, called Dum Dum, which used to be the Head Quarters of the Bengal Artillery, and which for a large number of years was a healthy station. As long as it was only an artillery station, it stood very high in the standard of health, although surrounded in every direction by rice fields, and low swampy ground. From the exigencies of the service, at the end of the second Seikh War, a larger body of troops was ordered to Dum Dum than the barracks were capable of containing with safety. I saw the 70th Foot march to Dum Dum on the very day that Sir Charles Napier, with whom I was at the time, landed in Calcutta. What occurred to that Regiment? At a station in which the health of the troops had always been remarkably good, it immediately began to deteriorate; and in the first year of its residence there, the 70th Regiment lost 25 per cent. of its strength, simply from crowding into a barrack that was otherwise healthy, and only capable of accommodating a third of the number then squeezed into it. I could multiply cases of a similar kind if I had time. For instance, one of the prisons under my charge, the jail at Moidapore near Moorshedabad, was abandoned in consequence of its extreme unhealthiness and reduced to the status of a lock-up. All long-term prisoners were ordered to be removed in consequence of the frightful mortality which prevailed, and necessity alone, caused to be retained there, a few men under trial, or of very short sentences. The prison went up immediately in the sanitary scale and became healthy, although it continued to be one of the worst built and worst placed prisons in the country. Save the numbers confined in it, everything remained unchanged. The drainage and conservancy were as bad as ever, and all the conditions of unhealthiness were the same as had previously existed; the absence of crowding was the sole difference. You might, in fact almost construct a sliding scale of the health of barracks and prisons from this condition only.

The first end accomplished has been more breathing room, and admirably has it answered. Many other improvements are, however, being gradually effected, and most creditable they are to the Government. There is no less a sum than £10,000,000 to be expended within the next four or five years in the building of new barracks or in remedying the defects of old ones. Each section of a barrack is to be separate and detached, and to contain no more than one company. This company barrack again is to be divided, with a room in the centre; and, what we have all been urging for years and years, namely that in a mala-

rious country barracks ought to be well raised above the ground so, that the men shall sleep out of the reach of the noxious exhalations from the earth, has been or is to be carried out. The soldiers' sleeping-room is to be a sleeping-room only; his day-room, his drill-room, his dining-room, his smoking-room, and his library are all separate from his sleeping-room.

What is the state of health in England itself of a manufacturing population where they are obliged to pig together in the same room; to eat, drink, sleep, smoke, and swelter, and thereby produce the thousand abominations that pollute the atmosphere they are compelled to breathe? Why, they die to an extent which horrifies the public, the overcrowding rendering them an easy prey to disease. This has been, to a considerable extent, the state of things with our European soldiery in India; and there is no better means of removing these effects than to diminish the number occupying the same room, so as to allow each a sufficient quantity of pure uncontaminated air to breathe. There are other sanitary conditions that are now equally attended to. Drainage is carefully regulated. Gardens are being established in which the soldier may amuse himself and gratify his taste, if he has any, for such pursuits; and, what is of still more importance, in which he can grow a large stock of the fresh vegetables, so necessary for his healthy nutrition. Instead of the dread monotony and ennui, the consuming idleness which drives the soldier to drink, under a recent order of Sir Hugh Rose, workshops have been opened. Soldiers have been encouraged each to adopt some handicraft, probably the one in which he was brought up before he was enlisted; and a late General Order of the present Commander-in-Chief in India, has shown, that a very large amount of success has attended this movement. There is no longer the same excuse for idleness and want of occupation, and the barrack has ceased to be the worst form of Castle of Indolence. To a soldier whose daily routine of life consists simply of his drill, and purely military duties, without any occupation for the remainder of the day, it is scarcely possible to imagine a more dreary life. There are other conditions also that are gradually undergoing change, and will, ere long be established for improving the health of the British Soldier in India. But let me earnestly impress upon you the fact that before any of these things have become accomplished facts—before a shilling of the munificent grant for barracks has been expended—before any of the excellent recommendations recorded in the Bengal Sanitary Report have been carried into effect, the condition of the English soldier in India has improved so much, that he is now in as good a sanitary condition, estimated by actual casualties, as Her Majesty's Guards were in London in 1857.

Another matter of very considerable interest and importance is the condition of the wives and children of the European soldiery. This is a subject deserving of the gravest consideration. The mortality among European women and children in India, is still very large—cruelly large. I am unable, however, to understand how Major O'Reilly the other day in the House of Commons, in speaking of the necessity for the rapid relief of troops in India, came to make a

statement which is unintelligible, and must surely be an error of the press. I have here a copy of his speech, as reported in the "Times." He says "The mortality among the women is no less than 276 per 1,000, and among the children 516 per 1,000;" that is to say in whole numbers, that one out of every four women dies annually, and that one-half the children born, perish every year. Where this statement could have been obtained I cannot understand. It is certainly not contained in Lord Stanley's report, nor is it to be found in that of Mr. Strachey. The rate of mortality among the wives and children of the soldiers is nevertheless sufficiently high. It seems to be about 44·5 per 1,000 among the women, and 90 per 1,000 among the children. Great as these numbers are, I have not the least doubt that they are susceptible of very considerable diminution even in the plains; and that the health both of the women and children may be improved, if the same means are applied to better their condition that have been applied successfully to the soldier himself. For instance, the mortality among English ladies, the wives of officers and civilians in India, scarcely rises above 14 per 1,000, as has been ascertained from tables constructed for the different Military and Civil Funds. But you must remember that the unfortunate wife of the soldier is in a very different position from her more happy and more prosperous sister. In the first place, the wife of the soldier is not a selected life, as that of the man himself is. The soldier marries the woman of his choice and there is of necessity no care taken that she shall be a picked life or a healthy subject. Again as a rule, they marry much too early in life. In other respects the hardships they used to suffer in barracks were very numerous and severe some years ago. I remember on one occasion, in 1840, when I was staying with the late Dr. Murray at Madras, at midnight information reached him that great sickness had broken out in the married quarters at Fort St. George. He went immediately, and I accompanied him, to see them, and anything more pitiable than the vast number of human beings whom I then saw crowded into a small space without any regard to the ordinary decencies and proprieties of life, it is hardly possible to imagine. Another case I may mention, that came under my own observation. When I was stationed at Fort William and in medical charge of its garrison, in the same year, the same thing occurred. A dreadful fever broke out, and in one large room in which forty or fifty families were crowded together, I was obliged to insist that every partition should be removed in order that some air might find its way to the corners and nooks of the room that the women and children might not perish from actual suffocation. All that is, happily, now a thing of the past. The effort that is being made to provide comfortable quarters for the women and children will no doubt improve their condition materially, and very soon exhibit a diminished rate of sickness and mortality.

The question of the children is a difficult one, and I am afraid that as long as they remain on the plains of India, the difficulty will not be entirely solved by any change that can be made. We need not, however, be surprised at the high rate of mortality of European

children in India, for I have looked at the latest records to which I have access, and find that the mortality of French children of pure European parentage in Algeria is about 93 per 1,000; very nearly, or, rather above the Indian average, great and dreadful as that is rightly considered to be. Mehemet Ali, who had 90 children of his own, was only able to rear 4 of them in Egypt, showing that the mortality in tropical countries is very great even among the young who are placed in much better circumstances than the child of the English soldier in India ever can be in the plains.

The fact is, that India is a singularly healthy country for well cared for European children up to 4, 5, or 6 years of age, as I believe my experienced medical brethren now present will concur with me in thinking. But after that they begin to pine and fade, they grow up thin and weedy, become scrofulous and die off rapidly, unless removed to England or the Hills. It is very easy to remedy all this, and for the children of the soldiery also. As I have already mentioned, Nature has provided the antidote to the evils of the plains, by girding those plains with high ranges of mountains. At a height of some 5,000 or 6,000 feet, there are climates the very finest in the world, in which, I have no doubt, that a healthy, vigorous, and manly population may be raised; one that shall enjoy as high a standard of health and physical development as the same class can possibly do in England.

An objection which has been urged to this is, that you may raise white men and women in these hills, but that you cannot raise Scotchmen, Englishmen and Irishmen, although their parents may have come from those countries. That is only true to a certain extent. You certainly cannot raise Englishmen, Scotchmen and Irishmen in tropical countries; but by education and all the surrounding influences which mould the minds of the young, I am of opinion that a European population can be raised on the hills of India, as manly, and in every respect as intelligent as their ancestors in this country. We do not hear of any degeneracy of the Highlander in Canada, or of the emigrant in New Zealand; and we also know that in all countries of the world, there is a natural tendency of mountain ranges to produce a sturdy and warlike population. I have not the least misgiving whatever, that if the scheme, which I have always advocated, were carried out, namely, the establishment of military colonies in the hill ranges of India, we should find therein the solution of one of our greatest political difficulties in India. If that were carried out, I doubt not also that a vast portion of this unhappy mortality might be prevented; and that the death rate might be reduced to the standard of the same class of the agricultural population in England, both as regards the women and the children.

There are various other matters to which I should like to have alluded, had time permitted. For example, clothing and equipments. There is no doubt that these must be modified to a certain extent with reference to climatic influences. Arms and accoutrements require a corresponding degree of modification. There are conditions of climate which render it necessary, as General Morris said the other day of the wear and tear of campaigning, to dispense with everything that is

merely showy and ornamental, and to restrict ourselves to all that is of real, practical use, and which cannot be destroyed by climate or by the other destructive agencies that are always at work upon them in India.

This reminds me of a statement which has been in circulation recently—it is only incidentally connected with my subject—with regard to arms of precision, breech-loading weapons, and rifled cannon, that the tendency of them would in the end be to cause battles to be fought like duels at long ranges, in which the leading qualities of the British soldier would be lost. This opinion was first promulgated by Sir Charles Napier, than whom probably no man ever saw harder fighting. I believe the contrary, however, to be the case. When I was at Chalons in 1861, shortly after the Italian campaign, a large number of the French regiments engaged in that campaign, and particularly in the battle of Solferino, formed part of the camp. I asked the question of the French officers, "What had been the result upon the conduct of these battles of the introduction of arms of precision? Has it led to duels at long distances?" They told me distinctly that never in the whole experience of the French army, had the bayonet been so freely used and with such disastrous effect as on those fields. As General Morris told us the other day of the recent American war, after the first blaze of fire was over, there was a pause, the lull that precedes the storm, then a cheer and a rush, and the works were taken! It was the same with the French. They closed as rapidly as they could, not depending upon the distant fire. After all, it is the pluck and training of the man who carries the weapon, rather than the mere qualities of the weapon itself, that continues to, and probably will for ever determine the fate of battles.

As regards clothing I can say but little. The only special matter of extreme importance connected with it, is the head-dress. There is no agent more active in the production of disease and death in India, than the sun which strikes the soldier from above; and all the devices which have hitherto been resorted to for producing a perfect covering for the head have been more or less failures. The hideous helmets now worn by the soldier in India, whether made of pith (sola), or with a cane foundation, are defective in one of the chief requisites of the soldier's head-dress in the tropics. It should be, as General Morris said, not only his fighting cap, but his night cap. It is impossible for him to sleep in a helmet of any kind. I believe myself that some modification of the turban will, after all, be the best solution of the difficulty. Mr. Jeffreys, who has written upon this subject, and who gave to the Royal Commission a large amount of ingenious evidence, perfect so far as theory is concerned regarding it, recommends highly polished metal helmets on the ground that a highly polished surface reflects light and absorbs little, if any, of the heat of the sun's rays. There is no doubt, however, that the weight of such a head-dress is a great obstacle to accuracy of fire; and besides in a climate like that of India all metallic surfaces soon become dull and dingy, and a helmet, without its polish, would, on a bright, hot, tropical day addle the soldier's brain. Therefore no sort of helmet or metal covering will ever in my opinion, answer in a hot climate. With regard to the

hair of his head, he is recommended by General Morris to cut it short, to dispense with brushes and combs altogether, and to depend for keeping it clean upon soap and water. So said also Sir Charles Napier. You may remember when he was sent to India a few years ago, according to "Punch," his baggage consisted of two shirts, a towel, and a piece of soap. He himself has said, "Why should a soldier have more coats than the commander-in-chief? I can do with one, why should he not be content with one?" To return, however, to the hair. I remember many years ago that a wag, who had charge of a batch of Cadets sent to Benares, led them to believe that hair was injurious in hot weather, and that the regulations required them to have their heads shaved at that season. Thereupon the boys had their heads shaved before reporting themselves to the general. When they went to the general's bungalow the officer who had charge of them put on his wig in the ante-room, and then introduced the cadets with their shaved crowns to the astonished general.

There is one other circumstance connected with the head-dress which I ought to mention, and which I think has been a departure from the right road. I see that most of the soldiers of the artillery and cavalry, and probably of some other regiments, now wear no peaks to their caps, and thus expose the head completely. However dandified it may make them appear at home, it will I am certain, be found dangerous in a country like India where the soldier requires every possible protection from the sun for his head and brain. The report of Mr. Strachey mentions that deaths from sun-stroke are on the increase, and it will probably be found on inquiry that much of it is due to the non-protective cap the soldiers wear. The old peak was useless, and anything but becoming in appearance; but the straight peak of the French kepi is not liable to the same objection, is certainly a screen from glare for the eyes, and is just as necessary as the curtain which protects the back of the neck from solar heat.

The form of the boots again is of great importance; and there is the subject of food and drink, on which much might be said. But the only remaining topic which I shall be able briefly to consider is that of acclimatation. Is it possible for the British soldier to be acclimated, that is to be able to stand the wear and tear of an Indian climate without injury to health? Can he attain to the same standard of health as that of the soldier in England? In the plains of Bengal, and of all alluvial districts he certainly would not. In the lower provinces he has to contend against an enemy that is ever active, and which there is no means of altogether avoiding, so long as the causes that call it into existence are present, namely heat, moisture, and the luxuriant vegetation, the decomposition of which produces malaria. We have evidence from the experience of Arctic voyagers, and from the evidence of African explorers, of the very varying conditions of temperature and climate which civilised man is able to bear, by accommodating himself somewhat to the change of circumstances in which he is placed. But this has a limit, and beyond that limit it is impossible for a native of Great Britain to become acclimatised in Hin-

dustan. There is no doubt, however, that he may become seasoned, and, as a seasoned soldier, be better able to bear all the burdens the climate imposes upon him, than the raw and unseasoned recruit.

It is most important, and many officers have insisted upon it for years past—one of them is now present Dr. John Macpherson, who has written strongly regarding it—that no growing lads, or boys of any description, should be sent to India, until the whole of their drill is completed in Europe, and their military duties are thoroughly learned. Growing lads are the most sickly of soldiers, and it is amongst them that the greatest amount of sickness and mortality occurs; but this is likewise the case in European armies.—Most of us have read of the large army collected at Boulogne by the first Napoleon, for the invasion of this country. By constant and careful drill and exercise, it became one of the most efficient forces ever assembled in the field. When he broke up his camp on the coast of France, and marched his army rapidly some 400 leagues, to fight and gain the great battle of Austerlitz, they scarcely left a man in hospital, or a straggler on the road, because they were all thoroughly trained soldiers, not one of them was a growing lad or a man under 22 years of age. Another army which under the same chief, in the year 1809, marched but a short distance to Vienna, filled the villages and encumbered the roads with their sick and dying, simply because the troops consisted of growing lads, who were unable to bear the strain of war, or fatigue of marching. Many of them were under 19 years of age.

Another period of life, at which it is impossible for the soldier to bear up against these influences is after he has passed the age of 40 years. But the soldier's career is generally included in the interval between the ages of 20 and 40, as his period of service is seldom prolonged beyond the latter age. It is certain that after 40, the soldier bears transplantation very badly. In India the great resource against climatic deterioration is our hill stations. If the soldiers in India were sent to the hills in larger numbers, and more frequently than they now are, there is no doubt that the necessity, on the score of health, of frequent reliefs from Europe would be obviated. The standard of health at these hill stations is very remarkable. At Darjeeling there is a school for children, which has been established ever since the station has existed; and from that hour to this, although many of the children were sent up sickly from the plains, not a single death has occurred from disease contracted at the station; yet they are of the very class of children who die in multitudes on the plains. The same may be said of the soldier himself. But the influence of the hills in his case is now known to be rather preventive than curative; therefore it would be better to send him there to recruit his health before it has given way, than to wait until he becomes diseased, and send him up to die, as too frequently happens at present.

This leads to another point which I should much like to have discussed had time permitted, namely the cause of the great difficulty in recruiting the army in India at the present moment, and the means of obviating this difficulty. There can scarcely be a doubt that in some, probably in a large degree, unwillingness to incur the risks of an Indian

climate is, in a measure, at the bottom of the paucity of supply of soldiers. It is certain that, from various causes, the army in India is not so popular, either with the officer or with the soldier, as it was in the days when the Indian Empire was under the charge of the East India Company. I do not mean to say that the withdrawal of a large portion of the army from the immediate authority of the Crown, was ever a right and proper thing—or that any sane man would for a moment advocate the restoration of the form of Government swept away by the Mutiny, by no means the least beneficial result of that disturbance. At the same time many of those best acquainted with India are of opinion, that as respects the army, the transfer might have been differently managed, with advantage. India is a peculiar country, and differs widely from all other portions of the British Empire. To render any body of men contented to spend a large portion of their lives in places, where for several months of every year, mere physical existence is a pain, it is necessary not only to pay them highly, but to give them an abiding and personal interest in the country, and its people. This can only be accomplished by a permanent force, such as was the European section of the Company's army, every man of which was content to spend the active years of his life in the tropics, and had made up his mind to do so before he left his home. It was emphatically a contented army, in which the greatest punishment that could be inflicted upon the soldier was expulsion from its ranks. The same is not the case now. Both officers and men are restless, and all who have not formed permanent ties binding them to the country, seem to be more anxious to leave than to remain in it. The race of men who conquered India, who were proud of their connection with it, who were content to bear patiently all its risks and minor miseries, and were prepared, in many instances, even to end their days there, has passed away: and so far as my personal observation permits me to express an opinion regarding it, as yet they have found few successors. Home sickness is the great moral endemic, and it is on the increase.

The present state of the European Army in India seems to me to afford matter for grave consideration in relation to its future government. To diminish the drain now caused by the large force employed in Hindustan, and to reduce the expenditure necessitated by the frequent relief of troops, are subjects which are hourly forcing themselves more strongly upon public attention. Among the means calculated to effect these objects I believe to be the establishment of Military Colonies in the Himalayas somewhat similar to those of Austria and Russia, of which I must content myself with the mere mention, as time will not permit me to dwell upon them.

I feel that I have given you a very imperfect account of what I intended to lay before you to-day. The fact is the subject is so extended that you must attribute the shortcomings of this sketch, more to the unmanageable extent of the subject, than to any unwillingness on the part of the lecturer, to place the matter fully before you to the best of his ability.

There is one little circumstance however that I wish particularly to

mention if you will bear with me for a moment. My friend General Eyre took away five minutes of my time, and I think therefore that I may be permitted to trespass a few minutes longer on your attention. I am strongly of opinion that too low a view has been taken of the influences which affect the health of the soldier in India—that too much has been attributed to climate and soil, and too little to the moral influences which surround the soldier in that country.

You have all doubtless heard that Calcutta is a terrible place to live in. People who have sent their children there, often think that they have taken a permanent leave of them. Many years ago when a boy was sent to India his friends believed, and probably hoped, that they had done with him for many years, perhaps would never see him again; or, if he ever turned up again, it would be as an old man with a full pocket and a yellow skin. Everybody remembers in the admirable biography of Clive by Lord Macaulay the astonishment of the father of the boy at the wonderful hero *he* had turned out, who was considered anything but a hero when he went away. Now, among the influences that affect a residence in India I believe that climate operates to a very considerable extent below what has usually been attributed to it, and I will tell you why I think so. In the course of last year, a report was published by Mr. Strachey, purporting to show the dreadful condition of European prisoners in Calcutta, and how every possible disadvantage in regard to their health was accumulated in the place in which they were confined. The statement, so far as the buildings and absence of proper sanitary arrangements was concerned, was absolutely correct: but the inference drawn therefrom was utterly incorrect. The Calcutta Jail was assumed to be a Golgotha which killed the majority of those confined in it. When the prison was placed under my charge, I examined its records most carefully, and had its medical returns scrutinized with the utmost diligence and attention. The result, I confess, surprised me not a little. I found that the most depraved, dissipated, and vicious of the European population of the Metropolis of British India—men who recklessly exposed themselves to every possible cause of disease, as soon as they were removed from their evil courses, and placed in a condition of enforced regularity, albeit in buildings of most unpromising sanitary character, instead of dying in crowds, became, in many instances, healthy and vigorous, and that the death rate of the prison in question had never been above the ante-Crimean rate of Her Majesty's Guards in London, even in seasons of the worst epidemic character.

A fair inference from this fact is that, however much sanitary reformers may guard against climatic influences, and improve the physical condition of the soldier,—equal, if not greater attention is needed to his moral welfare. In this all important matter it is, that the good influences of the officers of the army are required, and in which their constant care and attention may be most beneficially exercised. We all know that good officers, and particularly a good commanding officer, since on him most depends, make a good regiment—for to be a thoroughly efficient soldier needs, more than is commonly supposed, to

be a good man. Blackguards may, and do often fight well enough, as the history of fillibusters and freebooters proves; but a thoroughly good army must be a well-behaved, sober, and well-disciplined army, patient under all trials, and as conspicuous for good conduct in cantonments, as it is for valour in the field.

The discipline of an army depends chiefly upon the care and attention bestowed upon the men by their officers. This is a point on which I am unwilling to obtrude upon you my own opinions, lest upon the *ne sutor ultra crepidam* principle, you might fairly say, that as I do not belong to the purely fighting branch of the military machine, and the maintenance of discipline is no part of the special work of a medical officer, his opinions upon the subject cannot be worth having. Most of you are doubtless better acquainted with military history than I am, and are therefore familiar with the views of all great commanders on the point of discipline. No man, I believe, ever has or can be a great Commander, unless he is a strict disciplinarian.

As regards the soldier in India, I can adduce the testimony of two of the most distinguished men who have belonged to the Indian army in our time. In the second volume of the "Calcutta Review," in an article on the Military Defence of our Empire in the East, the joint production of Sir Henry Lawrence and Mr. Kaye, the eloquent and eminent Historian, both of them officers of the Bengal Artillery, this question is admirably treated.

In it is clearly shown that it is not possible to exaggerate the influence for good in the power of officers in dealing with and caring for their men. Paradoxical as it may appear, even so great an authority as the First Napoleon, in his military maxims has declared emphatically that valour is not the first quality of a soldier. And assuredly it is not courage of the highest order that has ever been found wanting in the British officer. Wherever danger is, there he is to be found, ever in the front. He is never known, when it is his duty to lead, to follow: his cry is, "follow me to do this,"—never go there to do that, of which he does not himself bear the brunt. It is but the other day, when a most distinguished regiment met with a temporary check in New Zealand, that the noble qualities of its officers were conspicuous in the highest degree. In a letter written to me by an eye-witness of the fact, it was stated that, in the belief of the writer, nowhere in the undying records of human valour is there to be found a higher example of heroic bravery than was shown by the officers in question when they stood alone to face the storm, scorning to yield an inch of ground to the foe. What said their noble-hearted Commander after a night passed in unutterable anguish from a mortal hurt, and amid threats of a cruel death from the barbarians by whom he was surrounded—what said he, unmindful of his own suffering when he saw his Commander on the following morning:—"General! I am ashamed to face you, for I have failed to do your bidding."

This is the stuff of which British officers are made—there is no fear, then, that the valour of leaders will ever be found wanting in them. But I concur with Sir Henry Lawrence in considering the duties of the Garrison to be of no less importance, although less showy

and exciting than those of the field, and that in them the officer will find the means of dispelling the *ennui* of the climate, and of contributing his full share to the happiness, and consequently to the contentment, and freedom from vice and its attendant train of ills, of the British Soldier in India.

The Chairman: I am sure none of you will regret the extra few minutes which our lecturer has taken. In fact the only thing to be regretted is that his time has been so limited, for it is evident that Dr. Mouat contains in his well informed mind the matter of a whole course of lectures. I am happy to be able to suggest that an opportunity, perhaps will be given to us of hearing him still further expound his ideas on this subject. As Captain Scott, who was to have delivered a lecture here next Friday is unable to do so, I only hope that Dr. Mouat may be persuaded to take advantage of that opportunity and supplement the present lecture with what remains to be said, especially on the subject of military colonization, which I believe will be found no less interesting than the lecture which we have heard, and, perhaps, even more important. By the aid of the British soldier we conquered India, and by the aid of the British soldier we must keep it; and whatever contributes to render India attractive to our soldier is of quite as much importance as to keep up our superiority in scientific matters, and in the material of war, for it is only by the aid of our soldiers that, however great our superiority in other respects, we can render it available and of advantage to the State; and therefore I hope Dr. Mouat will kindly yield to the proposition I have made.

Dr. Mouat: I am sure after the very kind reception you have given me to-day it would ill become me to refuse to comply with your request in any way. I consider this a very valuable Institution, deserving the support of every one connected with the army; and, therefore, so far as my humble services are concerned, I shall be most happy to contribute to its usefulness, by a compliance with your request.

LECTURE.

Friday, May 11th, 1866.

GENERAL SIR W. CODRINGTON, G.C.B., in the Chair.

THE BRITISH SOLDIER IN INDIA—THE MILITARY COLONIZATION OF THE HIMALAYAS.

PART II.

Dr. MOUAT: Sir William Codrington, Ladies and Gentlemen: Those who did me the honour of attending on the last occasion will remember that I endeavoured, but I am afraid very imperfectly, to show the vast extent of territory which has to be occupied and guarded by the British soldier; the large number of influences to which he is exposed in the performance of that duty; how difficult it is, in speaking of India, either in relation to the soldier, or, in relation to any other subject connected with it, to condense the vast amount of information necessary to its understanding within a reasonable compass. Even the subjects of soil and climate, differences of temperature, and mere physical differences, are so numerous, that a large number of lectures might be expended in the elucidation of that enquiry alone. I also told you that the very gloomy picture of the condition of the soldier in that country, and the large amount of sickness and mortality to which he was subjected, as pointed out in the report of the Royal Commission, that was first presided over by the late lamented Lord Herbert, and ultimately by Lord Stanley, was rapidly becoming a matter of history, even at the time the Report was written; and, now, has happily become very nearly a thing of the past. A large sum of money has been devoted, and will be devoted, to the purposes of buildings intended to improve the health of the soldier. But I think it only fair, as I told you on Friday last, to state that all the improvements that were suggested in that, or in any other report, for the purpose of ameliorating the sanitary condition of the soldier, have been represented, times out of count,

during the last thirty or forty years, by the various medical officers who have been in a position to tender advice to the Government on such matters.

Before entirely quitting that branch of the subject, I consider it necessary to notice especially, one other portion of this report of the Bengal Sanitary Commission, which has been printed by the House of Commons, and which may be, most likely will be referred to, in the course of the present Session of Parliament. It is a very able report, drawn up with remarkable ability, such as might be expected from the high position and the great gifts of the President of that Commission. At the same time, it is particularly satisfactory to me, as a member of the medical profession, to know that there is not one single recommendation, from first to last, contained in that Report that has not been, in some form or other, frequently urged by my professional brethren, proving that there has been no failure of duty on their part. The particular matter to which I wish to refer, now, is one of considerable importance; namely, the ravages of cholera in connection with the European soldier in India. It is shown here, in a manner that is very startling, that the mortality from that fearful disease has been increasing very considerably during the last few years; and has now attained proportions that are alarming. It appears that in the Bengal Presidency alone, since 1854, the per centage of deaths to treated for cholera, among the European troops, has advanced from 50 to no less, in 1863, than 75 per cent. It was reduced in 1864 to 72 per cent. The President of the Sanitary Commission who was also previously President of a special Cholera Commission, states that in his opinion a large amount of this mortality is due, either to positive mismanagement, or to the neglect of precautions which it was easy to adopt. He also surmises that some portion of it may be due to an actual increase in the intensity and severity of the disease.

Now, so far as my experience of it goes—(and very few men, I believe, have seen more of cholera than I have either in Europe or in Asia, for I have been familiar with that terrible disease since 1832, and during twenty-five years of residence in Calcutta chiefly among the European population and the sailors in the port of Calcutta, averaging 18,000 men a year)—I have not the least hesitation in stating, that to the best of my judgment, there has been no increase, whatever, in the severity of the disease, from the first day I witnessed it in Calcutta in 1840, to the day on which I left Calcutta last year. It is necessary, therefore, to look to some other cause for the purpose of ascertaining the real reason of this fearful increase of mortality. Mismanagement is a very general term. I would rather not enter into the question of what specific meaning is to be attached to it in the present instance—whether to neglect or to malpraxis on the part of those concerned in the treatment of the disease—but to show you that the supposed increased intensity of this disease is by no means a fact, I have merely to refer to the mortality of the same years, from the same epidemic outbreaks in civil hospitals among the native population, and in the native army.

We all know, yet perhaps you do not all know so well as I do, what a miserable, wretched class are the prisoners who are confined in the gaols of the Lower Provinces. They are among the most corrupt and depraved of the community. Many of them are in extremely bad health when imprisoned, the consequence of their own vices; yet among these people the mortality has not exceeded 37 per cent.*—a rate of mortality barely half that among the European soldiery, who are well fed, well clothed, protected, in some measure, from vicious habits, and who might be expected, therefore, to fall less readily victims to this disease than the miserable outcasts from society closely packed in overcrowded gaols. Among the native troops who are born in the climate, you would naturally expect a smaller mortality; yet among them it has never advanced to a higher figure than 57 per cent. This is a matter worthy of the most strict and serious consideration. I hold that if you eliminate cholera from among the causes of the high mortality of Europeans in India, you at once change the condition of risk of the soldier, particularly, in some parts of the country, so as to place him not very much below the standard of health that is enjoyed in ordinary service in a more healthy country. In fact in twelve stations in Bengal the death rate is below 10 per thousand already.

I do not, however, mean you to understand that the mere physical or climatic causes of disease are to be underrated or overlooked. At the same time, I think the error in the opposite direction, of looking chiefly to physical causes, as accounting for the deterioration of health, is equally unsound and equally incorrect. You may drain, you may ventilate, you may give ample space, you may provide pure water and abundantly varied food, and so on; but you will by no means have

* My knowledge of cholera since 1855 extends to all parts of the Lower Provinces of the Bengal Presidency.—Dr. Morehead, of Bombay, the author of the best existing work on Tropical Diseases, and an officer of extended experience in Western India, concurs in the views mentioned above; and such I infer to be the opinion of Dr. Edward Goodeve, my successor in the Chair of Medecine in Calcutta, in his recent admirable monograph on Cholera in Reynolds's System of Medicine.

Dr. John Macpherson, an officer of ability and of large experience in India, has more recently published opinions to the same effect.

Every one of the many epidemics of cholera that I have witnessed had some peculiar characteristic of its own, and some varied remarkably in intensity from others; but, as a rule, my impression is, that, except in particularly unhealthy localities, such as Purneah and Burrisaul, the average intensity of the disease had rather diminished than increased.

The following numbers afford much ground for reflection and indicate the urgent necessity for careful inquiry by competent professional men, for the opinions of the most gifted men beyond the pale of the medical profession, are of no authority or value in such a question.

The percentage of deaths to treated among the classes mentioned, in Bengal, was as follows:—

	European Troops.	Native Troops.	Prisoners.
1862	61·3	50·3	36·4
1863	75·1	57·0	36·5
1864	72·6	44·0	36·6

These numbers tell their own tale.—F. J. M.

removed the soldier from a very large number of causes of deterioration to which he is liable, and which are more destructive in a tropical than in a temperate climate, unless you operate upon him by moral means and moral agencies. Improve him in education; above all, make him more sober and less reckless than he usually is; and give him such an amount of occupation or amusement as will keep him out of temptation; for, depend upon it, a large proportion of disease in India is due to idleness, and the vices to which idleness leads—and there is no form of idleness more hurtful than that of life in a barrack in hot weather, where the soldier has nothing to do but to lie on his cot, eat, drink, smoke and sleep all day long, and sally forth at sunset to indulge in destructive dissipation. If physical agencies were the chief and greatest enemies to be encountered, all that we should require in the way of sanitary agents of reformation would be a broom and a pail of white-wash, or a carpenter with a foot rule to measure space, or a "navvy" with a spade to regulate drainage. And here I at once fall upon a fact which shows how difficult it is to discuss these questions without local knowledge. It has been stated that the want of subsoil drainage is at the bottom of a very large amount of mischief. Now, I ask any man acquainted with engineering in any form, how you are to drain by artificial means, vast tracts of level country in which if you poke a stick into the ground for six months in the year, not half a dozen inches below the surface, you constantly meet with water. What will become of your subsoil drainage during the six months when the whole country is flooded with the rains. It is not, however, at that time that the most destructive diseases occur; it is when the mass of that moisture is undergoing slow evaporation from the surface, during the gradual subsidence of the floods. Nor is the remedy feasible on the large scale that would be necessary for sanitary purposes, from the enormous cost of draining any great extent of low, marshy country by the least expensive means available. For instance, in the case of Calcutta, about which so much has been said and written, a scientific system of drainage is now being carried out at a great expenditure of money, and there is some reason to fear that it will fail from causes easy to understand. Should it unfortunately miscarry, it will cause more mischief in the way of disease than it is capable, if successful, of removing.

To come, however, without further preface to the special object of my lecture to-day—it being necessary in a discussion of so wide a range to limit the portion that can be considered in a single hour—given the great and gradually increasing difficulty and cost of maintaining the large European force required for India, how can the drain and strain upon the resources of Great Britain be best diminished by simple and practicable means?

There is at the present moment a very large amount of valuable life that is not only not turned to good account, but actually wasted in a most distressing way. I have already mentioned to you the enormous number of casualties among the children of the European soldiers, amounting to 90 per thousand; and the large number of

deaths among the wives of the same class, amounting to no less than 45 or 46 per thousand of women in the prime of life. This is a terrible mortality. And when we reflect upon the fact, that it is quite capable of being mitigated or diminished, until it shall not exceed the loss among the same class at home, I think it is incumbent on us, on every ground of policy, expediency, and humanity if we can show the means of remedying such a lamentable evil, to do so.

Fortunately, for us, there is scarcely a single part of the whole vast continent of India in which there are not mountain ranges, springing from the plains to heights which possess climates in which the European can live and thrive as well as he can possibly do in his own country; or in our more healthy colonies of New Zealand, Australia, or Canada. I believe there can be no doubt whatever upon this point. Mr. Brian Hodgson, a distinguished member of the Bengal Civil Service, who spent thirty years of his life in the Himalayas, and who traversed almost every portion that was accessible in his time, has placed his views on this point on record. He wrote a special paper on the subject, in 1856, to show that, in his belief, this range of mountains affords climates and soils that are perfectly and admirably suited to the European constitution in every respect. There is present in this room another officer of great acquirements, who spent an equal portion of his life in that part of the world—Dr. Campbell, of Darjeeling, who is of the same opinion. Again, all those who have brought scientific knowledge of the highest order to bear upon the examination of the mountains of Hindustan, Drs. Hooker and Thomson, the late Wm. Griffith, and several others who have written regarding it, all tend to a belief in the same direction, viz., that they are in every way adapted for habitation by Europeans. Upon the strength of the unimpeachable evidence recorded by such skilled witnesses, I am justified in assuming then, that these mountains are perfectly capable of being inhabited by the natives of Great Britain.

The next question with regard to the founding of colonies or permanent settlements in these hills, especially for a practical nation such as we hold ourselves to be, is, that they should pay, and possess within themselves the means of self-support. For, to be a constant source of expense, or of unprofitable outlay, would absolutely unfit them for the purposes of colonisation. This, I think, although it has not been subject to the same amount of rigid demonstration as climatic influences, is equally susceptible of proof. We have only to examine the soil and see what it is capable of producing, to know that there is scarcely a variety of the cereals, the grains which form the food of man, that is not capable of being produced, and grown in any quantity, according to the area of cultivation, among those hills. In the next place, European fruits and vegetables with very few exceptions, and those exceptions only in particular places, where there is too large an amount of moisture to permit some of them to ripen, all come to maturity in profusion and perfection. You have, then, almost all the vegetable productions of temperate countries, and those of the tropics can be grown in the valleys, or be obtained from the plains in sufficient abundance and at no great cost to maintain European communities living in the hills.

So much then for those productions of the vegetable kingdom which are used as food by man. In addition to them articles of great commercial value can be grown, such as tea, which is already cultivated to a very large and remunerative extent, and the Cinchona plant which thrives admirably, and will hereafter become one of the most valuable productions of the Himalayas. With regard to the animal kingdom, we should not expect an English colony to thrive in any country where they could not get beef and mutton, and a sufficient supply of the animal food to which they are accustomed. There is no doubt that herds and flocks may be reared in different parts of those mountains, differing in quality as regards their fleece and flesh, but practically unlimited in quantity. Pigs and goats flourish and thrive—so does poultry with proper care and management. In addition to feeding the Colonists, a thriving trade might be established in wool, teas, hides, horns, &c. This being the fact, then, and the animal and vegetable kingdoms supplying all that is necessary for the maintenance of a community, I do not think it necessary, even if time permitted of my doing so, to enter further into details to prove that the colonization of the Himalayas is practicable, if carried out with judgment, and the means and appliances necessary.

Mr. Hodgson, when he wrote on the subject, had in his mind colonists such as now emigrate to America and Australia, and I am told that a Mr. Hyde Clarke,* whose pamphlet I have not seen, has written on the same subject, with reference to the extension of railways in India with a view to prove that the Himalayas afforded an eligible field for the emigration of the agricultural and other classes who now seek homes in the New World or at the antipodes. I will attempt to show you, that the colonization of the Himalayas by time-expired soldiers is still more practicable, and that, in existing circumstances it is a measure of economy as well as of sound policy. Not that I should select a soldier as affording the best material for a colonist,—but having the soldier in India already, great expense having been incurred in taking him there, and further cost being needed to bring him back to where he is not required,—why not turn him to the best account in India, and encourage him to settle there!

The great want of the Himalayas is labour—for without it, fields cannot be cultivated, forests cleared, or flocks and herds be raised.—The indigenous population of the hills is very sparse, and they are too lazy and capricious to labour continuously.—Their work is consequently costly, and emphatically bad, and it can never be relied on.—Here then is a wide and profitable field for the utilization of the soldier, when his time of service has expired, and he is anxious to convert his sword into a pruning hook—in fact, to return to civil life again. The old form of enlistment for life was a piece of barbarism that has disappeared with the progress of civilization, and could not again be reverted to, even if it were desirable in itself. Short terms of enlistment are then a necessity of the times, and are among the causes of

* See also Journal Royal United Service Institution, vol. iii, p. 19, Lecture on "The Organization of the Army of India, with especial reference to the Hill regions," by the same author.—ED.

the greatly increased cost of the army.—The free labour market now comes into very injurious competition with the supply of soldiers and sailors—for like everything else, it is controlled and must be regulated by the ordinary laws of supply and demand. A cheap army in a time of unexampled prosperity, when every branch of human labour is rising in value, is an impossibility. Like cheap and unskilled labour elsewhere, the worst and not the best variety would be procurable at the lowest market rates; and I hold that nothing short of the best men who can be induced to serve will be really useful, or fitted to fulfil the purposes of an army in a country which is to be held by the prowess and discipline of that army.

Having then obtained the best material at a high cost, and expended much money in its perfection as a military machine, by the short term of enlistment, every soldier discharged at the end of his ten years is a loss to the State at the very time that he is most valuable. It has cost £500 to maintain and make him what he is, and it will take an equal sum to replace him, should he be unwilling to re-enlist. There can be no compulsion in this matter—so it seems to me that the next best thing to do, is to render the loss as light as possible—and this I am of opinion can, in no way be so well accomplished as to hold out to him sufficient inducement to settle in the Himalayas,—there to found a new home, and to rear a healthy and happy progeny. The wives and children who perish in the plains, would live and thrive in the hills.

Upon this point I would rather quote the opinions of soldiers, than impress my own views upon you—for none but those intimately acquainted with the soldiery possess a knowledge of their proclivities, such as to render their opinions valuable. Sir Henry Lawrence was probably one of the best soldiers, and certainly one of the best men whom England, in a time when good soldiers and good men have been neither few nor far between—has produced. He has left his mark upon the history of the country in which he spent his life, and he illustrated his blameless life by his heroic death, exhibiting the extent to which the great principle of duty actuated him from first to last. For is there not a record on his tomb that is as great in its way, and will live as long as Nelson's signal that "England expects every man to do his duty:"—is there not, I say, on Henry Lawrence's tomb the simple inscription dictated by himself—"Here lies Henry Lawrence, who endeavoured to do his duty."

This great soldier, whom I hold to have been better acquainted with India than any man of his time, who had studied it thoroughly, and who was equally well acquainted with the British soldier in that country, strongly advocated the grant of lands in the Himalayas to the soldiers, as the best means of diminishing the mortality among themselves, and more especially the greater mortality among their wives and children—and of thus rendering them happy and contented. He held, in addition, that a large body of trained and disciplined Europeans permanently settled in the hills would form a valuable reserve always at hand, and would materially strengthen the army in the plains, should it ever be required to repel invasion from without.

General Eyre, who presided at the last meeting, who is again

present, and who was the first officer who brought victory to our standards, and turned the tide of the Sepoy revolt, has also strongly advocated the military colonization of the Himalayas. Other Indian officers of ability and experience, who have written on the subject have urged the same measure.—I think, then, that I am not wrong in taking it for granted that the employment of English soldiers in the manner indicated has the sanction of some of the most experienced soldiers who have thought and written on the subject.

An appeal to history to learn what other nations have established military colonies, will afford us examples that we may follow with profit, although, perhaps, not without considerable modifications, because the despotic rule of those countries differs so essentially from the freedom of England, that the *modus operandi* of the one could in no way be applied to the other.

Most of you are, I dare say, aware that Austria long since placed what are called "Confins Militaires," or Frontier Regiments along the borders of that portion of her territory, which was in contact with the dominions of Turkey. They formed military colonies, chiefly intended for defensive purposes,—but always liable to be called into active services, and appear to be among the forces now embodied for the great struggle that is supposed to be at hand. Their organization is too strictly military, and they form a Military Caste governed by stringent regulations that could never be applied to colonies of English soldiers in the Himalayas, or anywhere else.

The Emperor Alexander of Russia in the course of the great war with France, visited the Austrian military frontier settlements, and resolved to establish a similar institution in his own Empire. His object was partly to people and bring into high cultivation parts of his dominions in which neither abounded; but this end was subsidiary to the creation of a Military Caste, which should to a great extent be self supporting; should form a valuable reserve from which he could at all times recruit his army, in case of need, with healthy, well trained troops of all arms; which should protect his frontiers from attack; should render secure all additions made to Russian territory; and should ultimately when fully expanded, render conscription unnecessary by furnishing more soldiers than would ever need to be embodied, even in that military and aggressive Empire.—Soldiers of all arms were accordingly quartered in considerable bodies upon the serfs of the imperial domains, and a complicated military organization was devised for the conduct of the scheme.—At first it seems to have been equally unpopular with soldiery and peasantry, and in many instances was violently resisted by the latter. The measure was, however, persevered in without heed to resistance; defects were corrected as practical experience was gained; and so large an amount of success was ultimately attained, that the Emperor Nicholas revisited the Colonies in 1837, and, exhibited to a great concourse of military spectators of all nations, a remarkably fine body of admirably trained soldiers, born, bred, and drilled in his colonies.—Marshal Marmont speaks highly of them in his Travels in Russia, and experienced observers from different countries mention them as decidedly successful.

How they have fared since the emancipation of the serfs I have no

means of knowing, nor is there any information extant to which I have access to show how these Military Colonies met the strain of the Crimean War, in which such prodigious losses were sustained by Russia.—The system on which they were based is of necessity altogether inapplicable to any body of English Colonists, but many of the details of arrangement were excellent, and would bear transplantation with advantage. It seems to me, therefore, to be very desirable that exact information regarding them should be obtained by the deputation of trustworthy eye-witnesses.

The most simple and sensible plan, and the one most likely to succeed in the Himalayas would probably be that of the French in Algeria. In February 1847 an ordonnance was promulgated to establish Agricultural Camps, in which lands were to be granted on certain conditions to soldiers who had served, or were then serving in Algeria.—The time passed in these Camps by officers, non-commissioned officers, and privates was to count as active service entitling to pension on retirement for five years—by which time it was hoped that the settlements would prove self-supporting. A grant of three millions of francs was sanctioned for their establishment, and the greatest care was to be exercised in the selection of the Colonists, all of whom were to marry, if not provided already with wives, as a condition of their selection.—This scheme of civil colonization by the employment of the army was much discussed in France at the time, chiefly with reference to the question of acclimatation. The probability is that the experiment failed, because it is now generally acknowledged that Europeans *pur sang* can never become thoroughly acclimatised in tropical plains, and all the settlements proposed were in the plains. As a mission has recently been dispatched to Algeria, authentic information on this point has doubtless been obtained.

Among all the plans above mentioned, I can imagine no great difficulty in selecting the parts best suited for trial with British soldiers in the Himalayas. It would not, of necessity, answer to attempt the establishment of a Military Caste, or to fetter the freedom of the colonist by any injurious restrictions either as respects himself or the disposal of his children. The compulsory choice of a profession is inconsistent with our ideas of liberty, yet in the case of the father a grant of land might be associated with a certain amount of military service, and from the healthy progeny that ought to be reared in the mountain ranges of India, a fair proportion of candidates for a short term of soldiering would in all likelihood be obtained.

Is it likely, then, that the children of English soldiers, born, bred, and educated in the Himalayas, would degenerate, and form a less manly population than their progenitors? It is impossible at the present time to adduce positive proof on this point, inasmuch as the experiment has not yet been tried. I believe myself that there would be no physical degeneration. All the geographical conditions necessary for the propagation of a hardy race exist in those mountains. Thews and sinews are not wanting in the native races. India contains no more warlike people than the Goorkhas, and a multitude of the fierce fanatical tribes who are a perpetual thorn in the side of the

Punjab government.—Natives of the plains, even the effeminate Bengalies, become robust and healthy when acclimated in the hills referred to. Nature having fulfilled her part of producing a healthy and vigorous population, the rest may safely be left to moral influences, to education and association. We hear of no degeneration of the immigrant population of Canada and New Zealand, and the lineal descendants of the Pilgrim Fathers play no unimportant part in the present history of their country.

To discuss further the formation of the character of the descendants of Englishmen in the mountain ranges of Hindustan would open up the whole question of the history of civilization, and render it necessary to show the influence of their institutions upon the moral development of a nation; how far these are affected by climate, soil, food, industrial occupations and the thousand other circumstances that mould a nation; and how far the institutions themselves re-act upon the physical conditions in which a people are placed.—Give them a good education, surround them by the influences which their parents have brought from their own homes, and the free air of the mountains will do the rest. One of the Himalayan settlements, Darjeeling, already contains a third generation of pure blood, and there is no appearance of falling off, so far as I know, in them. On the other hand, there exists no example of a third generation of Europeans of unmixed parentage in the plains of Hindustan.

Thus, again, the question of the acclimatation of Europeans in tropical countries crops up. I have already mentioned, the very limited extent to which I consider it possible in the plains. It divides itself into two distinct stages. For the first we have no scientific equivalent to the term *acclimatement* used by the French, which may however be freely rendered into English by the word "seasoning."

When an inhabitant of a cold country proceeds to the tropics it is necessary for him to abandon some of his old habits, to avoid exposure to the sun with an uncovered head, to make such changes in his dress as may enable him to bear a high temperature without exhaustion, and to change his dietary to the extent required by the new conditions to which he is subjected. By this means he gradually becomes seasoned, or capable of resisting climatic influences with an amount of impunity that is denied to the new comer. This is seen every day and nearly every hour in India. The last example that I am acquainted with is contained in this report of Mr. Strachey.

The mortality at Lucknow was higher in 1864 than at any other Bengal station, having amounted to 44·5 per 1,000, of which 15·8 was caused by cholera.—The garrison consisted of the 107th and 36th Foot, the 5th Lancers, and a battery of artillery. The 107th was an old regiment, originally in the Company's service, and which has never left the country since it was embodied. Its loss, and that of the artillery which had also been some time in the country, was comparatively small. The great loss was in the unseasoned regiments, the 36th and 5th Lancers. All the troops in the garrison were exposed to the same influences, and were equally well off as regards quarters, food, &c. The only condition of absolute difference between them was

the more recent arrival of the two regiments in which the great loss occurred—showing that seasoning is of some consequence in such matters.

It is sometimes argued, and I see the argument reproduced in the parliamentary discussions on the subject of the soldier, that long residence in India causes him to degenerate, and that he needs frequent removal and renewal to prevent his losing some of his fine military qualities. Likewise, that continued service in India causes increased sickness and mortality.—I do not believe either of these views to be correct, and the extent to which they are true is not only very limited, but perfectly susceptible of explanation. Numbers, so far as the statistics of sickness and mortality are concerned, may by manipulation without any intention to deceive, be made to prove anything. Monsieur Quetelet has shewn, that 35 years is the age in Europe, of what is termed the greatest vitability, or in which the value of life is highest, and that after this age, the chances of death increase as life advances. To this extent India obeys the general law, but I am not aware that it increases the risk of the seasoned, after 35, to such extent as to form a special law of mortality for that country. The contrary is the result of my personal experience of a quarter of a century. That the old seasoned soldier in India is a less valuable fighting animal than the new comer is entirely disproved by past experience in that country both among Royals and the late Company's European forces. King's and Queen's regiments formerly remained so long unrelieved, that few of those who went out in them, lived to return. The Company's regiments spent the whole of their military lives in India, the survivors returning to Europe only when unfit for further service from age or infirmity.

Ever since the first Affghan war there has been constant fighting in India, on a scale never before witnessed, and consequently constant opportunity of testing the fighting qualities of the European soldiery. With what result? So far as I know, or have ever heard, no Royal regiments were ever in better fighting trim than at the conclusion of their Indian career, when climate had done its worst upon them.*

* A multitude of examples of this might be given. Among those known to me were the 16th Lancers and 3rd Light Dragoons in the first Sikh war; the 10th, 29th, 50th, 80th, and many other infantry regiments in the same campaign; all the old regiments engaged in the suppression of the Sepoy mutiny, for Delhi was taken before a single fresh soldier arrived in India. Lucknow was defended by seasoned troops until relieved by Havelock and Outram; and Greathed's column consisted of a portion of the Delhi field force. Of the Delhi force itself, all the corps being equally exposed, and having equal shares of fighting, the Company's European regiments, bore the strain of war with least loss and suffering. If the records of the Indian army for the last half century were carefully scrutinized, I am quite certain that the same result would be found to be constant and invariable.—F. J. M.

Since the above note was written I have been told by one of the most distinguished officers alive at the present time, that he saw the 1st Bengal Europeans and the King's 76th Foot, a famous regiment in those days, go into action together at Deig, some sixty years ago, and that for brilliant fighting, it was impossible to perceive any difference between them. The first named corps was then nearly fifty years old, and had passed the whole of its life in India: the 76th had only been a short time in that country. —F. J. M.

The illustration afforded by the Company's Europeans is still more convincing, for up to the present moment, with the exception of a brigade of Horse Artillery, none of them have ever left India since they were originally raised. In the very last campaign, of which little has been said or written, but which was one of the most creditable feats of arms ever performed in India—the Umbela Campaign against the fanatics of the North West Frontier—the brilliant daring and stubborn endurance of the old regiments were objects of general admiration to all who witnessed them. During the Sepoy Mutiny, if I have been rightly informed—and my information came from many of the misguided men themselves when imprisoned—the old were much more feared by the Pandies than the new regiments, although there were among the latter some of the finest corps in the British army. The cause of this was, as I understood, that the old regiments closed more rapidly, and went more thoroughly in at them—some degree of contempt for their old acquaintances being most probably at the bottom of it.—Be that as it may, the Sepoys never stood long against the cheer and the rush in the open plain. A story was current at the time, which illustrates my argument. An old Soubadhar covered with medals, some of which dated back from the days of Lake, Deig, and the Delhi of the beginning of the present century, was asked why he and his brethren who always fought well under the guidance of their European officers, behaved so ill, and made so little stand in the Mutiny. His reply was: "It is quite true, Sahib, our hearts are valiant, and our courage as great as ever—but the moment we heard the British shout, and saw the Europeans closing on us, our rascally legs carried us in the other direction, and overpowered our hearts." It was the cheer and the rush that did the work.

Has the world ever seen a finer body than the old Company's artillery of the three Presidencies? Their greatest eulogists have been their most eminent commanders—whose prejudices and predilections, if they had any, for they are Royal officers to whom I refer—would have been in the opposite direction. Sir Charles Napier after an unrivalled experience in war, pronounced the Indian Artillery as being perfect from fifteen years of constant campaigning. In the Mutiny, when the Royal and Company's gunners were for the first time associated in the field, not only was no inferiority detected in the latter, but they were regarded with admiration by their brethren of the same arm fresh from Woolwich, and were highly prized for their efficiency and their rough and ready qualities by their Commander the late Lord Clyde. Finer artillery, in fact, did not exist. Remember then that the men of the old Indian artillery had spent the whole of their lives on the plains of Hindustan, for there is no artillery station in the hills; many of the older men among them had been fifteen or twenty years in the service, and had been exposed to every possible climatic cause of deterioration, without the smallest diminution of their military virtues.

This disposes, I think, effectually of all arguments for rapidity of relief based upon any supposed deterioration from long residence and service in India.

And now to return to our project of colonization, which I am afraid

I am treating somewhat discursively. Seasoning in the plains is a salutary and useful process, but, in them, the second stage of complete acclimatization is for Europeans altogether impossible and impracticable. One of the principal causes of the great amount of cost incurred by the large European force now employed in India, is the supposed necessity for frequent reliefs. I have attempted to show that such reliefs are not a necessity of climate or of military efficiency—for if, in what are now olden times for India, before the days of railways and hill stations, Europeans had a fair chance of life with ordinary care and attention, and suffered no loss of military prestige and efficiency, still less can they be considered necessities when so much has been done, and with such excellent effect, in improving the condition of the soldier. The necessity is undoubted, but is altogether one of the present conditions of service, and a direct result of the abolition of the permanent European force formerly entertained. In fact so far as health is concerned, the necessity would disappear entirely, if the bulk of the European Army were cantoned in the hills, and the term of service at unhealthy stations in the plains were limited to short periods. The standard of health of a regiment in the hills ought to be as high as that of the most favoured quarters in Great Britain, and would be so, by proper care and management. The sanitary condition of many of these hill-stations was, until very recently, by no means as good as it might be, were more attention paid to those conditions that would be necessary for the maintenance of health in Paradise itself. For the European army there is an abundance of land available, the climate is as good as their own, probably better—and the most perfect acclimatation is not only possible, but proven.

For the bulk of the European Army then, the question resolves itself into one of the military defence of the Indian Empire, a topic to which I can devote but a few passing remarks:—yet it is one that might be discussed with great interest and advantage in this Institution. The most interesting monograph on the subject that I am acquainted with, is that of Sir Henry Lawrence to which I referred in my last lecture. It was written in 1844, long before the establishment of railways, and before the experience of the real source of our weakness in India, as prophesied by Sir Henry, was shown by the Sepoy revolt of 1857. He was of opinion that three-fourths of the European Infantry, and half the Dragoons and Artillery might be placed in the hills.

The doctrine now advocated is that 20 per cent. is the limit, with reference to strategical purposes. I am inclined to rely far more on Sir Henry Lawrence's judgment, which has stood the test of time, and the roughest handling to which the English power has ever been subjected in India, than to that of any other authority with whose opinions I am acquainted. He had studied the question carefully, and possessed a more intimate knowledge of India than any other man of his time.

Irrespective of strategical questions, part of the objection to place the greater part of the European army on the hills, is I believe, one of

expense—the European Soldier at present costing far more in the hills than he does in the plains. This arises from the greatly increased cost of food and necessaries, and from the very expensive establishments now entertained. The former might be diminished by producing the principal articles of consumption, including beer, in the hills themselves,—and the latter might with advantage be dispensed with, even in existing circumstances. When a European regiment ascends the mountains, it takes the whole of its Native Establishment with it, and a very ragged regiment they form, of cooks, barbers, washermen, tent-pitchers, *et id genus omne* of "tag rag and bob tail," as every one familiar with India knows. In a European climate the English soldier ought to be made to perform all those duties which he discharges without question and of necessity at home—instead of being waited upon by a wretched collection of shivering, half clothed natives of India. There would be no difficulty in the matter in the hands of efficient Commanders, as I can show by reading to you the opinion of an officer of great experience, Colonel Robertson of the 6th Foot, which I am able, by the kindness of Dr. Campbell of Darjeeling, to lay before you. The following is an extract from a note written to me by that gentleman: "There is one suggestion connected with "cantoning European troops on the hills which I have not seen advo- "cated, but which is worthy of serious consideration. It has refer- "ence to the greater expense of maintaining the men in a good "climate than in bad ones; an objection which has long told against "countervailing advantages. Col. Robertson of H. M. 6th Foot, "commanded his regiment at Darjeeling when I was there. He was "an experienced and very zealous officer, and was very successful "in establishing workshops, and other useful occupations for the "men.

"After careful attention to the climate of the hills; and having "served in all quarters of the globe, he came to the conclusion that "the men could do everything for themselves in the Hills that they "do in England; and that the whole array of native camp-followers "who cost so much in the plains and are doubly expensive in the "Hills, might be dispensed with during the turn of duty of each "Regiment there.

"His plan was, that a Regiment occupying a Hill Station for the "first time should on arrival there dispense with all its cook-boys, "barbers, washermen, water-carriers, scavengers, tent-pitchers, &c., "and that the relieving troops from the plains should make over to "the returning one the whole of these native followers along with its "elephants, camels, and all other means of transport required for "marching in the plains.

"Colonel Robertson was by no means a rash man, and no one had "the welfare of his men more at heart than he had. He knew what "British soldiers could do, and what would suit them; and he would "gladly have tried his plan to help in removing objections, on the "score of expense, to giving our soldiers the benefits of good climate "which are so pertinaciously denied them."

There is no doubt that if this were done, two great advantages

would result. In the first place, a larger amount of what is very much wanted in the Hills as well as in the plains—occupation—would be given to the soldier. I have been in Hill stations with the soldiery. There is at present no earthly amusement in those places for them; their duties are very light; they have a parcel of poor native attendants to perform operations for them which they could do much better for themselves, and they are sorely puzzled to devise the means of killing time. Now, by getting rid of so much of the expenditure at present incurred, a very great objection to cantoning large bodies of European Soldiers in the hills would be removed. It would carry with it, the subsidiary but by no means secondary advantage of taking the women and children there.

Some writers of authority in India consider it to be visionary to advocate the wholesale transfer of the children of the English soldiers to the hills on account of its expense, their views being that each child would cost as much as it takes to educate a gentleman's son for a profession at home. The maintenance and education of a boy or girl at the Lawrence Asylum now costs £40 a year, which is a very modest sum to assign for any kind of professional education in England—and this amount is much greater than need be, or would be incurred by the establishment of schools on a more extended scale, and under a different system of management.

If we had large bodies of Europeans quartered in the hills, either in cantonments or colonies, the children ought, in a very few years, to be brought up there at rates little exceeding those of children of the same class in England. Whatever the cost however, is it not incumbent on a Christian Government which owes so much to its European soldiery, to diminish the distressing mortality among their children, by every means in its power without regard to cost? The expenditure would prove an economy in the end.

In what manner, then, ought military colonies to be established in the hills, so as to ensure all the conditions of success? I have been told that the experiment has already been tried, and that it failed, so that when General Eyre revived the question, at the time that India was transferred directly to the rule of the Crown, it was not deemed advisable to subject it to a further trial. But how was it tried? A few worn-out old pensioners were taken from the the hottest rock in India, Chunar, which is at the same time the head-quarters of chronic intoxication, and were sent to Cherra Poonjee, on the eastern range of the Himalayas, the wettest place in the world. It is difficult to give to any one unacquainted with the locality, the faintest idea of its characteristics, and of the extreme changes to which the ancient votaries of Bacchus were subjected, without a suspicion of exaggeration. The rain fall at Cherra may be calculated in yards, rather than in inches, for the down-pour averages more than 600 inches, or 50 feet of water annually. I once spent three days there in the height of the rains, and they were the most amphibious days of my life. To approach the place we steamed across a lake some forty miles in extent, with the river Soorma winding through it with a tortuosity that would have broken the heart of the river God, Mæander. The

villages in this vast liquid plain appeared to be dotted about in a most eccentric fashion, but were in reality placed on the high land forming the banks of the stream, as I found when visiting the place in the dry season, when the water had run off, and the lake was converted into a gigantic rice-field. The steamer passed through the main street of the villages, in some places almost brushing against the roofs of the huts with her paddle-boxes. The inhabitants swarmed on the tops of their houses to stare at us as we passed, the steamer in which I was, being the second that had ever been seen in that part of the world, and the first that had wound its way across the lake in the rains. It is now better known, being the high road—indeed the only road—to the tea gardens of Cachar, then a wilderness, now containing an active, enterprizing European population of 3 or 400 persons. We produced a great and unexpected commotion among the dusky damsels who came forth to look at the steamer, by turning our glasses towards them. They shrieked and disappeared very much as frogs dive when a boy throws a stone at them, and on enquiry we found that some Bengali wag had told them, that spy-glasses possessed the property of turning every one upside down, towards whom they were turned!

When I reached Cherra, the cause of the flooding of the low country was apparent enough, and realized the classical description of the mountains from which Deucalion looked down upon the floods in the deluge of mythology. In the three days of my stay, it rained 23, 24, and 26 inches—each of them more than the annual rainfall of some countries. Indeed, I was once shown a man at Cairo who had come in from some place in the desert, and who, although seventy years of age, had never seen a shower of rain. To ride from one bungalow to another, at Cherra between the showers, was usually a hot race, for with every precaution in the shape of macintoshes and waterproof boots it was sometimes impossible to escape a thorough drenching, however hard you galloped. The effect was very much as if the Serpentine were taken up into the air, and suddenly upset on the heads of the riders in Rotton Row without warning.

To this station, in which all soil is washed off the rocks, and which is damp in the last degree, the baked old pensioners were suddenly transferred from Chunar, with nothing to do and no one to look after them. The poor old fellows soon began to shiver and shake, they crept into their dens, and to keep out the rheumatics, took to strong drinks in a fashion that converted their chronic into acute intoxication, under the influence of which they rapidly disappeared, as might have been expected.

It is not of such material that I wish my military colonists to consist, but of sober, steady, healthy young men, with wives and growing families, men able and willing to cultivate the soil, and to become the pioneers of civilization, as their countrymen have been in so many parts of the world, where great and wealthy cities have displaced dark and dismal forests,—and where howling wildernesses have become smiling plains, from the results of human labour.

I believe the picture which I have drawn of the senile settlement of Cherra Poonjee to be by no means over-coloured, although I perceive among my auditors an officer intimately acquainted with the facts of the case, who shakes his head with an air of doubt. In any event, I am sure that he will concur with me in considering that the experiment was not fairly tried; that its failure proves and teaches nothing; and that it might be tried again under such conditions as to give it a fair chance of success.

The soldier who has been cared for all his life, and has never been called upon to exercise the smallest amount of thought regarding his maintenance, or the disposal of his time and talents beyond the pipe-clay cycle of military duty, needs some guidance to start him in life as a colonist. The plan best adapted for that purpose, inasmuch as it would leave him the largest amount of personal liberty, and call for the smallest return in the shape of Military Service, would probably be that of the French in Algeria to which I have already referred.

A couple of officers on the same condition of service as the men were appointed to control and regulate the affairs of each of the Agricultural Camps; the villages were constructed on fixed plans to secure every necessary convenience, as well as to combine economy with efficiency: the implements and other materials for husbandry were provided; and the whole settlement was on regular pay for a period not to exceed five years. If they have failed—and I have no information on the subject—the failure must have been due to climatic causes, and to the camps being placed in the immediate vicinity of hostile Arabs—neither of which conditions would occur in the Himalayas.

My plan then would be this. I would in the first instance select most carefully, 300 well conducted, healthy soldiers whose term of service had nearly expired: and I would take equal care that my intended colonists had healthy, well conducted wives, with young families. These 300 families I would form into one village community, with grants of land of sufficient extent to admit of their supporting the village, when fully cultivated. To each village I would appoint a Captain and Subaltern, married men with growing families, to control and direct it in all matters in which guidance was required. The officers should also have grants of land and become *bonâ fide* settlers, and they should be armed with all the powers necessary for the entire management of their charges. Medical attendance and education, with which religious offices and instruction should be combined, I would likewise provide—every member of the community having his grant of land and being thoroughly identified with it.

In addition to attaching some light condition of military service to each soldier settler, from each family I would exact the condition, suggested by Sir Henry Lawrence, of supplying a recruit for service for ten years to the European force in India.

By some such plan as this carefully worked for five years, the practicability of Military Colonization would be fully tested, at a cost that could be more easily borne by the revenues of India, than

the large outlay now incurred in sending time-expired soldiers to Europe, and removing regiments without any real necessity as frequently as seems to be contemplated, on pleas of health and necessity which are utterly untenable.

The French calculated that £40,000 was sufficient to plant and maintain each of their military camps until they were self-supporting: the same sum would probably be found sufficient in the Himalayas. I would plant three such colonies to test the matter completely—one in the Western Himalayas, a second centrally, in the vicinity of Darjeeling, at about the level of Hope Town or Lebong, and the third in the new settlement of the Eastern Himalayas, to which the station of Cherra Poonjee has been transferred. Officers and men possessing all the necessary qualifications could, I am satisfied, be easily found—and the plan itself would, I am certain, be hailed with satisfaction by the European soldiery in India. It would also, I believe, produce a feeling of contentment that does not now exist, whatever may be the cause.

The old Company's Europeans were emphatically a contented army; the men were attached to the country and did not desire or care to leave it. Their officers were equally well satisfied, and none of the grievances which are now so prevalent, were ever heard of. The cause is obvious and on the surface. Men and officers had alike a permanent attachment to the country; it was to their interest to cultivate kindly feelings towards the natives; and all were content to take their Indian service, as they took their wives, for better or for worse, and to make it practically a life engagement.

Such is not the case at present. Every regiment sent to India looks or hopes for a speedy return; regards its Indian service as a disagreeable banishment; and has no thought of taking root in a tropical soil. The soldier at the end of his ten years either pines for home, or leaves the army to better himself, or is unwilling to continue to serve without increased pay and better prospects of advancement. It is true that he can remain in India if he forms local ties, or prefers the country for any other reason by volunteering; but this breaks up his home—he leaves the regiment which was his first love—and has to begin his military life again in a new regiment which has no sympathy with him, and which will for very long regard him as an interloper.

No Colonel will, if he can help it, let his best men go, and few good men care to leave a regiment to which they are attached, which is well commanded, and in which they like their officers. As a rule, I have heard it said by those who ought to be well acquainted with the matter, that the worst men are those who most frequently volunteer, and that a regiment can be made too hot to hold those whom every good commanding officer is anxious to get rid of. The result must be that the worst soldiers remain in a country in which the best are needed; and that crime and increased disease and mortality are among the logical consequences of the present system.

It was not so in the old system. The soldier's first regiment was his home which he only left for some staff appointment, or when his time of service was at an end. I am, therefore, strongly of opinion

that the question of a local European army should be revived, and in it I see the solution of much of the present difficulty in recruiting. At all events the present plan has failed; the amalgamation has satisfied no one connected with it, with the probable exception of the few who have personally benefited by it; and the necessity of devising some new method of rendering the army attractive has become a necessity.

Formerly the greatest punishment that could be inflicted on the Company's European soldier was to turn him out of the army and send him home. Now most of the Europeans in India are home sick, and craving to leave the country. Whether this new form of nostalgia is increasing in intensity, and whether much of it may not be due to the now rapid communication with Europe, I am unable to determine. But, I think, that a return to plans which produced contentment for a century, and the departure from which has been followed by chronic discontent, would tend much to mitigate, and might possibly remove the present difficulties. I do not in the remotest sense advocate the revival of the grand old Corporation which is dead and buried, and is rightly a thing of the past. There is I am convinced not a soldier of the old army, who is not proud of being a Queen's soldier, or who would willingly consent to the severance of his direct title to be so considered. At the same time I am satisfied that it would be wise and politic to renew, in an improved form, the old ties to India, and to give to the soldiers the means of becoming settlers, which bind them so strongly to Canada, New Zealand, and other colonies in which they can now have grants of land on favourable terms. In those countries, I believe, they have proved among the best of the colonists, for their military service, and the strict habits of obedience and self-control in which they have been trained, are, if they are only moderately sober, the best preparations for good citizenship in civil life. If, therefore, the incentive to good conduct that would be produced by grants of land in the Himalayas to the well behaved, were held out to the soldiers in India, with the protection that would thereby be afforded to their wives and children, it would certainly make them contented to remain in India; and by establishing military colonies in the Himalayas we should acquire a stronger hold of the country and render more material assistance to England for its retention than by any other arrangement that can be devised.

Beyond the question of the competition of free labour, the increase of emigration, and the rise in wages, with recruiting on the present terms—in which soldiering being the weakest, must go to the wall—there is, I suspect, a good deal of dread of service in India among the classes from which recruits are obtained. It must be remembered that, according to the last returns, there are only 12 per cent. of the men now in the army who are unable to read. All that has been recently written of the great risk to life in India, with the painful pictures of disease and death that have been painted by Royal Commissions, is reproduced in exaggerated forms by the penny press, and penetrates to the remotest villages in the country. Every man who now enlists, unless it be in the Household Regiments, knows that

he must of necessity have his term of Indian service; and an undue dread of India has taken firm root in the public mind.

Might not one or two of the professors of Military History, who are now supposed to be more numerous than is necessary, be profitably employed in dispelling the delusions regarding the risk of an Indian life!

My time is up, and I feel that I have treated this question in a manner quite incommensurate with its importance. I trust, however, that I have succeeded in showing that it is possible to colonize the Himalayas; that their colonization by English soldiers would ultimately be a measure of economy; that it would save a large amount of valuable life, particularly that of women and children that is now needlessly wasted, and is the cause of much misery and suffering to those who are unable to protect themselves; that a healthy, vigorous, manly white population may be raised in the mountain ranges of Hindustan, and that such a population would form the best possible barrier against the hordes of Central Asia, and furnish the best means of resisting attack from within or without, in any possible contingency that may arise in that country.

I know of no current question that could be discussed with greater interest and effect than that of the military defence of the Indian Empire. By the very last mail has come the intelligence that Sir William Mansfield, the present gifted Commander-in-Chief in India, recommends the immediate reduction of the European Force in that country by 5,000 men, improved means of communication having multiplied the power of the European army, so as to render a smaller force by concentration and rapidity of movement, equal to what required a much larger expenditure of power a short time since. Whether such a reduction be prudent and politic, no man can have better means of knowing than Sir William Mansfield. At the same time it must be admitted, that whatever diminishes sickness and mortality, and keeps the men in vigorous health, multiplies the power of those men to a degree that cannot be fully represented by figures. Such a measure I hold to be the occupation of the Himalayas by the bulk of the European army in India—and the formation of a reserve of incalculable value to future times by the establishment of military colonies in that magnificent range of mountains.

Whatever may be the result of the discussions as to the maintenance of the present system, or the restoration of a local army, I am thoroughly convinced that Her Majesty possesses no more loyal and devoted subjects, his Royal Highness the Commander-in-Chief, no men more contented to serve under him, and England no sons better able or more willing to uphold her honour on all occasions, than the British army in India.

The CHAIRMAN: For the kindness of Dr. Mouat in giving this lecture, and for the intelligence he has displayed in dealing with the subject, and the information he has communicated, I am sure I may ask for your best thanks. It happened that General Eyre did not arrive in time to take the chair on this occasion; and I do not know whether he wishes to make any remarks. No subject can be more

interesting than the management of our army of 60,000 Europeans in India. Every detail, Dr. Mouat has brought forward in a manner to elicit our warmest admiration, and in the name of the members I beg to tender him our best thanks.

Evening Meeting.

Monday, May 7th, 1866.

W. STIRLING LACON, Esq., in the Chair.

NAMES of MEMBERS who joined the Institution between the 30th April and 7th May, 1866.

LIFE.

Robinson, G., Captain R.N., 9*l.*

ANNUAL.

Tryon, G., Captain R.N., 1*l.* Buckle, C. M., Captain R.N.

DESCRIPTION OF ELASTIC PADS INVENTED BY THE CHEVALIER ANGÉLINI, GENERAL AND AIDE-DE-CAMP TO H.M. THE KING OF ITALY.

Translated and read by CAPTAIN A. B. CRAUFURD, R.N.

THE object of this system, invented by General Angélini, is to protect saddle and draught horses from galls, continually caused by saddles, pack-saddles, and harness.

The inventor was led to make a study of this subject by the consideration of the great number of horses, which, in the belligerent armies during the last campaign in Italy, were put *hors de combat* in a short space of time.

This disadvantage is so serious and so important that almost every Government, since that epoch, has sought to find means of avoiding it, but up to the present moment they have not succeeded, having been unable to discover the true cause.

The French Government attributes the loss, to the ranks being filled with recruits unaccustomed to the saddle, and to young horses not

sufficiently trained (vide the report of General Grand for the year 1861).*

This cannot be the true cause, since the Austrians, who had men and horses perfectly instructed, had also a great number of horses knocked up.

The Italian Government assumes that the cause of sores to horses is due to the great weight which they have to carry, and to the negligence of the soldiers.

Lastly, the Austrian Government attributes it to the bad shape and quality of the saddles, but none of these is the true cause; for officers of the three armies mentioned, who are doubtless good riders, who have taken every possible care to preserve their horses, and are provided with better saddles, of two-thirds less weight than those of the soldiers, had their horses galled in the same proportion as the latter.

General Angélini sustains, on the contrary, that this evil is caused by the the covering and the panels, as well as by the saddle.

In fact, the *Covering*—

1. By the material of which it is made, by its size and thickness, produces great heat on the back of the animal, and thus renders him more susceptible to gallings.

2. It possesses very little elasticity when new, and rapidly loses this quality by use; it hardens by the perspiration mixed with dust, and also by blood running from any sore.

3. It slips from under the saddle.

4. It often wrinkles.

5. It reverses and eradicates the hair.

6. When wet, it augments considerably in weight and heats beyond measure the back of the animal, by producing a reaction on the blood analogous to that produced in a hydropathic cure.

The *Saddle* always causes galls—

1. It causes them, in the first instance, when it is not adapted to the back of the horse.

2. It causes them, above all, after a march of four to five hours, when the girths becoming slackened allow it to change place.

3. In war, when the saddle is always the same, whilst the back of the horse, becoming smaller, changes daily in form, sores become frequent and inevitable, and disable the horse for service during the period of the campaign.

From the consideration of these various points, the inventor is convinced that to prevent gallings caused by saddles, in the three cases above-named, as also those caused by harness, there is no other means than to substitute for the covering and panels, pads sufficiently elastic, so that where the saddle or harness presses too hardly, the pads should yield in equal proportions.

The inventor is also convinced that to preserve coolness of the back, it is only necessary to make these pads of an anti-caloric substance, and so formed as to allow a free circulation of air over all the back.

* At Solferino, out of 10,000 horses, within two months, only 3,000 were left.

To obtain the advantages described, the inventor has manufactured pads of a size equal to the side bar of the saddle, or of the parts of harness which sustain the chief strain, constructed of a certain number of tubes of vulcanised caoutchouc united together. These pads are fixed to the saddle and harness, so as to form an integral part of each.

By means of this system the following results are obtained :—

Coolness Maintained.

1. In consequence of the anti-caloric quality of the substance.
2. By means of the air which passes through the tubes and between the two pads.

Lightness.

Because the two pads are half the weight of the covering.

Lastly, a very great *Elasticity*, which produces the following advantages :—

1. It protects the horse from all sores. The tubes compressed too much, either by the weight of the rider or by the convexities of the back of the horse, yielding in virtue of their individual elasticity, and the others resisting, it results, that all the tubes support an equal weight without causing any pain.

But to elucidate more clearly and fully these advantages, it will suffice to show that, placing the hand under a pad, and upon the latter the weight of one or two men, no pain is experienced in the hand.*

2. It protects the back of the horse from shocks and shakings occasioned by trotting, leaping, and too sudden halts in rapid motion.
3. The animal breathes more freely, for at the moment of inspiration, the pad yielding, the girths slacken sufficiently to facilitate that function.
4. It also lightens very much the weight which the animal has to carry, because it is equally spread over all the surface of the pads, and does not bear upon one point alone, or partially upon several points.
5. It modifies the movements of the horse to the rider, and fatigues him less.

These pads have also the following secondary advantages over woollen coverings.

1. They cost less, and last longer.
2. They enable a horse to be saddled more easily and more rapidly.
3. Saddles fitted with these pads cannot turn easily, as it often happens now with woollen coverings.
4. The pads being much thinner than the coverings, the rider sits nearer to the horse, firmer in his saddle, and has greater command over him.

* It is remarkable, on the contrary, that if the weight is distributed equally over the surface of the pad, the tubes, however weak or small they may be, support an enormous weight by the strength they gain by being fixed one against the other.

5. All possibility of wrinkles, which frequently occur in coverings, and often gall and tear the skin of the animal, is avoided.

6. The saddle cannot move forward or backward so easily, because the grooves formed between each tube, and the equal pressure over all the surface of the back produced by the elasticity of the caoutchouc, give a great power of adhesion to the pad. In consequence of this power of adhesion, the crupper is rendered useless, and it is not necessary to strap the girths of the saddle so tightly, thus avoiding the chance of the animal's sickening or being restive.

7. The free space between the pads allows the dorsal spine to move freely, without feeling any pressure or pain, as often takes place with coverings.

8. If a horse should even suffer from sores, swellings, or bruises on the back, he can be used without retarding his recovery, for, in such a case, it will be sufficient to remove from the pad as many tubes as required, or to prepare a pad on purpose, which should leave the sore part untouched.

9. These pads are impermeable; they can, therefore, be placed on wet ground, and even in mud, without damage to them. Thus you are enabled to preserve in a dry state the saddle and pack, a very important question on occasions of bivouacking.

Description of the different forms which can be given to an elastic substance for making Pads.

The different forms which can be given to an elastic substance to serve as pads, are five in number:—

A. That of a sponge	Plate xviii.,	Fig. 1
B. That of mamelon	„	„ 2
C. That of tubes	„	„ 3
D. That of dice	„	„ 4
E. And, finally, that of double tubes		„ 5

The forms preferable are those of single or double tubes.

The size of the tube is proportioned to the weight to be carried.

For example: Single tubes for cavalry saddles will have a minimum interior diameter of 18 millimetres, and a maximum thickness of 4 millimetres.

Form and application of Pads.

Pads for saddles and pack-saddles (one on each side) can be made in two ways.

1. The tubes can be glued, riveted, or sewn vertically on a band of leather or caoutchouc (see Fig. 7).

2. They can be cast in one piece (see Fig. 6).

The pads for Hungarian saddles and for pack-saddles can be made by the above two methods.

Notwithstanding that during the very conclusive trials, which have

ELASTI
(Angelini's
Various forms of the material

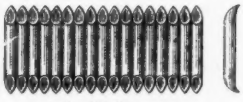
Fig. 1.

As Sponge.

Fig. 3.

As Double T

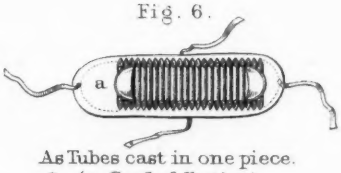
Fig. 3.



As Tubes.

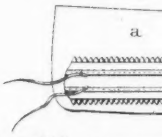
PADS FOR SADDL

Fig. 6.



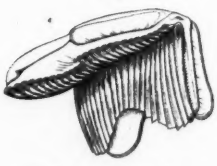
As Tubes cast in one piece.
(a. Band of Fustian)

Fig.



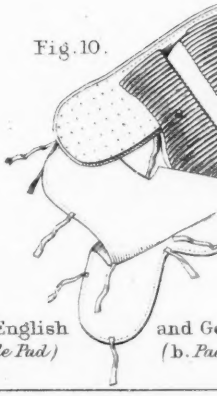
As Tubes separat
(a. Band of

Fig. 9.



Pack for Mule.

Fig. 10.

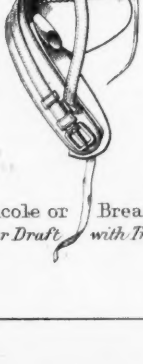


Pads for English
(a. Simple Pad)

and G
(b. Pa

PADS FOR DRA

Fig. 12.



Bricole or
(For Draft

Breast Band.
with Trace Bars)

Fig. 13.

Collar.

Fig. 14.

Bri
(For D

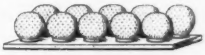
J. Jobbins.

TIC PADS.

gelini's System.)

e material to be used for making Pads.

Fig. 2.

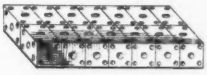


As Nipples.

Fig. 5.

s Double Tubes.

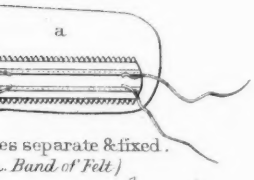
Fig. 4.



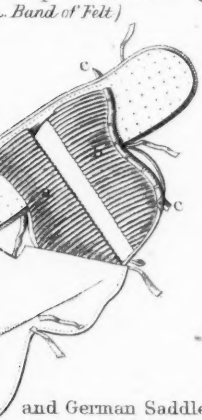
As Dice.

SADDLES AND PACKS.

Fig. 7.

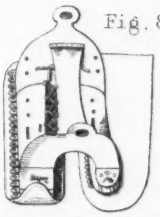


es separate & fixed.
. Band of Felt.)



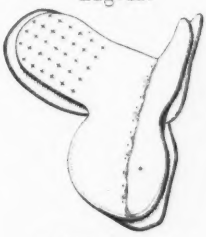
and German Saddles.
(b. Pad with distributer Tube c)

Fig. 8.



Military Saddle called Hungarian trimmed.

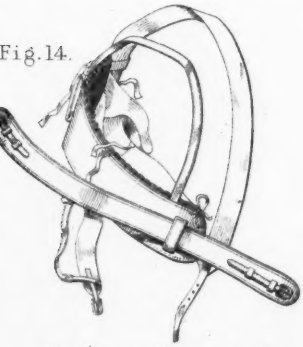
Fig. 11.



English Saddle.

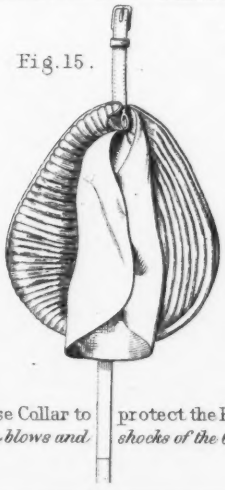
R DRAFT HARNESS.

Fig. 14.



Bricole or Breast Band.
(For Draft without Trace Bars)

Fig. 15.



False Collar to protect the Horse.
(From blows and shocks of the Collar)

lasted for ten months, in three regiments in Italy, the pads of caoutchouc were placed in immediate contact with the back of the horse; in order to satisfy those persons who seem to fear that the grooves marked on the back by the intervals between the tubes, and the disadvantages which might result from the particles of sulphur contained in vulcanised caoutchouc, we admit the interposition of felt, made of hair, but not of wool, between the horse and the pads, which obviates all those disadvantages, and prevents the rubbing or wearing of the hair occasioned by the friction of stirrup-leathers and packs, and the pressure of the girth-buckles (see Fig. 7, letter A).

Pads for English or German saddles will consist in preference of tubes cast in one piece and slightly curved or cut obliquely at their extremities, in order not to damage the hair of the horse.

These pads will take the place of panels in the upper part of the saddle, and will be placed between the two linings vertically, with the upper ends of the tubes on one side, distant at least five centimetres from those of the tubes on the opposite side (see Figs. 8 and 10).

It will be necessary to pierce the upper part of the pad with a certain number of holes, in order to obtain a free circulation of air.

To render the seat in any saddle softer, it can also be stuffed with very small tubes or with a sponge of caoutchouc.

Pads for harness should in preference be cast in one piece, and be applied as in Figs. 12, 13, 14, and 15.

Fig. 14 represents the linings for breast-leathers adapted for *bricoles* for horses harnessed to vehicles without trace-bars, and to obviate the rigidity of a fixed trace-bar, which produces a dangerous friction, and causes sores on the shoulders and withers.

Fig. 12 represents an ordinary *bricole* furnished with tubes for draught with trace-bars.

Fig. 15 represents an immovable lining called a false collar, over which is placed the ordinary collar, with or without tubes.

This false collar has the double advantage of protecting the animal, not only from the gallings caused by friction, but also from the shocks so frequent when the horse throws himself on his traces, which seriously injures the muscles of the shoulder, and very soon disables artillery and omnibus horses, obliged to stop and to start at all moments.

If this system is advantageous to the army by preserving its cavalry, it is more so by preserving its beasts of burden for transport service; for it is a real disaster for it to run short of provisions and munitions, as too often has been known to have occurred, in consequence of numerous and severe sore backs, which placed mules *hors de combat*.

Lastly, it is of the deepest importance for the army, in preserving its artillery, since, through a single gall, you risk the loss of horses, men, and guns, when the animal, galled by the collar, or the *bricole*, will rear or throw himself down, rather than draw his traces.

Captain CRAUFURD: The General has mentioned to me that during the operations of the campaign in Algeria the French had 3,000 mules to carry their provisions and ammunition, and within six weeks, from sore backs, they had only 200 mules left

and consequently for three days they were without provisions. I may also mention that, although this principle has been applied to animals, it can also be applied to relieve soldiers from the weight of their packs; a system of tubes is introduced in the same way; the weight is spread over a wider surface instead of pressing upon one point, and the man carries the weight without feeling that he is carrying it.

Captain FIELD: Can you give us an idea of the comparative cost between this new system and the old plan of stuffing the saddles? I apprehend it will make a very great difference in the cost.

Captain CRAUFURD: The question of expense has not been gone into. The General states that the use of these tubes will do away with two things which are in use at present, the covering and the stuffing of the saddle. This, which you see at present, and which is a rough sample of what may be put into the saddle, costs seven francs, and although it might even cost more, the advantage of saving the horses will very soon cover the extra expense. I may mention that I took General Angélini to see Mr. Macintosh, a gentleman who knows more about the manufacture of india-rubber than anybody else. He was very much struck with the idea. Several questions have been raised in Italy, where they have tried it very successfully. The experiments that have been made, practically, by three cavalry regiments where the horses have been saddled three days and three nights continually, and all the reports given by the colonels of the regiments have been most flattering. The Italian Government may be a little backward because they do not understand in that country the manufacture of india-rubber. It is thought by some that the sulphur in the india-rubber will injure the horse, but Mr. Macintosh laughed at the idea. It is also thought that the heat of the horse's back may injure the india-rubber. Mr. Macintosh says, with respect to that, that india-rubber will stand a heat of 130 degrees without injury. The General wishes to put the pad next to the horse's back, but to meet any objection he proposes to put felt between. But the great object of this plan is to have the pad next the horse's back, because if you put felt between the tubes and the back, you lose the great tenacity which these tubes have on the back, and you have also increased the weight. I may mention that in the Society for the Suppression of Cruelty to Animals they have adopted india-rubber for the purpose of catching vermin. The leg of the animal is caught in the trap, but is not broken, I have heard it described, but I have not seen it. The vulcanized india-rubber is applied to the trap and when it shuts it catches the animal, but does not hurt it in the least. These traps have been out winter and summer, and the Secretary of the Society assures me that the india-rubber was not the least affected by the weather.

Colonel MAYER: I think it would be an immense advantage to get rid of everything between the tubes and the horse. In the first place the less you have to take care of the better. In the next place I think the horse's back would be much cooler with the tubes next him than if he had felt between the tubes and his back.

Captain CRAUFURD: The felt is made of hair, hair being a non-conductor of heat.

Colonel MAYER: It appears to me that if the plan has been tried and it has been found that the sulphur in the india-rubber does not hurt the horse's back, the question is whether the felt under the tubes would not cut into the horse's back.

The CHAIRMAN: If no other gentleman wishes to say anything I will give our best thanks to the Chevalier Angélini for his paper, and to Captain Craufurd for having translated and read it.

ON A NEW FORM OF RIFLED PROJECTILE FOR SMOOTH-BORE ARTILLERY, CALCULATED TO OBVIATE THE NECESSITY FOR RIFLING ORDNANCE.

By Captain J. H. Selwyn, R.N.

In introducing to your notice this evening a most important and ingenious invention, I am not, as is sometimes the case with those who read papers here on such subjects, liable to the objection or impeded by the consciousness that "self-praise is no recommendation." The discovery or invention has been made by Mr. John Macintosh, and I am only the humble instrument in bringing it forward.

It will not, I hope, be thought tedious if I shortly recapitulate the heads of the existing theory of modern rifled ordnance.

In the search after greater efficiency of artillery which it became necessary to make when the means of defence were augmented by the adoption of iron armour for vessels, the use of elongated shot and shell was resorted to principally in order to obviate, as much as possible, air resistance, by increased weight and diminished diameter of projectile. Thus it was expected that greater range would be secured. But that these elongated bodies might be transmitted at high velocities in a determinate direction, it was supposed to be necessary that they should be made to rotate on their longer axes during flight. To ensure this, the device of grooving or rifling the gun was revived, after having been long abandoned by artillerists, at least for military purposes, and then commenced the battle of the grooves which has been waged with no less warmth and spirit, at perhaps even greater expense, than was once the famous railway battle of the "gauges." It is not my purpose to go into such questions now; it may suffice to say, that in this, as in most other cases, experience is teaching us, day by day, the value of the *least complicated*, the *most simple*, means that can be used, to produce the effect we seek.

It has been shown, by more than one artillerist, how by balancing the projectile scientifically, an equally good effect in keeping it point foremost may be obtained, with that produced by rotation as above described; but other objections have hitherto prevented such methods from coming into use, and we have been, up to the present moment, content to accept the necessity for grooved guns, with short lives—heavy shot with low velocities—and costly projectiles with light bursting charges. The nation has spent a very large sum of money and much valuable time, and now knows considerably more of what ought not, than of what ought, to be done in artillery.

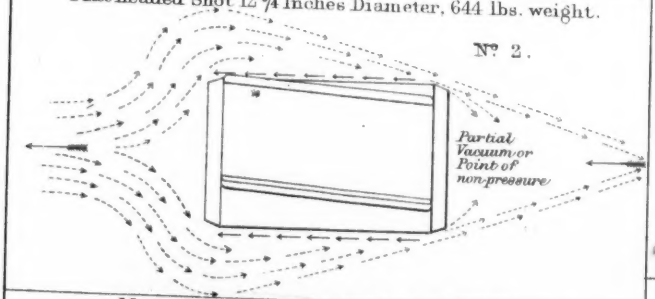
The device of setting a shot or shell in rapid rotation by causing it to unthread a screw in order to get itself out of the gun, is one which must necessarily throw a very considerably increased strain on the piece that is subjected to such treatment. What this strain amounts to, may be better understood by comparing the initial velocities of smooth-bore and rifled guns than by any other method. When the progress of the attack and defence had made evident the necessity for ordnance of enormous calibre and shot of equally increased weight, under such a strain, no mode of manufacture, no metal could be found that would enable a gun to stand the charges of powder theoretically requisite to produce the best effect. So we went from multigrooves to shunts, from shunts to multiforms, and landed at last, eschewing alike complicated breech-loaders and unsatisfactory coils, at smooth-bore muzzle-loading guns with reduced charges, and with very little of the new welding or any other novelty about them. It cannot be denied that whether it be that what we have is not good, or that what is good we have not, there has been no such thing as a really satisfactory result up to the present moment. We have not, we are far from having resolved the question, What are the best forms or material for modern ordnance?

It is under these circumstances that I venture to solicit your attention to a new projectile which may be fired from any of the old smooth-bore guns with a velocity, a range and an accuracy, greater than that obtainable from any rifled gun, at the same time that no more strain need be thrown on the gun than has been the case in the former days of round shot and spherical case. In order to make clear what are the difficulties it is sought to combat, what are the methods of accomplishing the result, I have prepared four diagrams which I will now proceed to explain:—

In diagram No. 1, Plate xix, is shown a portion of the path of a spherical shot through the air. The one here represented, for greater convenience, has a diameter of 12¾ inches, and might be fired from the Blakely 640-pr., or any gun of that calibre. Its weight would be about 320 lbs. Its velocity might be 2,000 feet per second, or 1,363 miles per hour. Now, when we recollect that the velocity of a hurricane is given as about 100 miles by Telford and others, that the force of this is also given as about 146 lbs. to the square foot, and that this force will increase as the squares of the added velocities, we shall not be surprised to find that the force opposed to such a shot, moving with this velocity, neglecting the reduction for spherical form, would be about 27,000 lbs. per square foot. The section of this shot would be about 127 square inches, or 17 square inches less than a square foot. The blue lines which surround the shot are intended to give a rough idea of the way in which the air is thrown aside and meets again; the black arrow showing the direction of the shot's path, and the small red arrows close to the surface of the shot, the air which is supposed to be retained by the effect of friction as an atmosphere carried along with the body in motion. These are repeated in each diagram. In No. 1, it will be observed, that the air after being parted meets again with comparative ease, owing to the spherical shape which is dividing

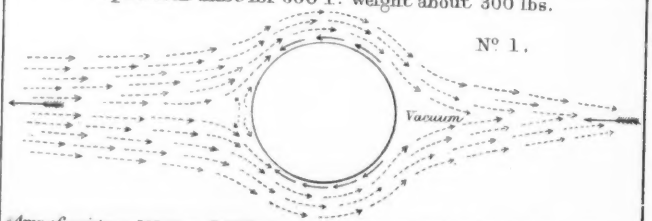
Flat-headed Shot 12 ¾ Inches Diameter, 644 lbs. weight.

Nº 2.



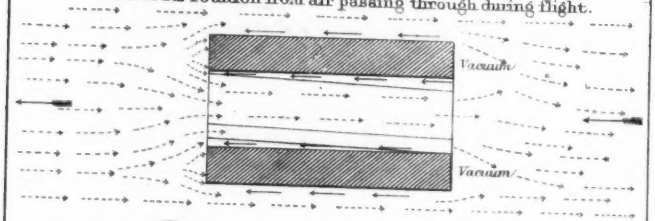
Spherical Shot for 600 Pr. weight about 300 lbs.

Nº 1.

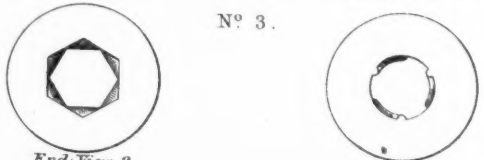


Area of resistance 127·67 sq. Ins. Velocity say 2000 Ft. per second or 1363 Miles per Hour
adverse pressure 58 lbs. per sq. Inch, non-pressure over say ⅔ of hinder surface.

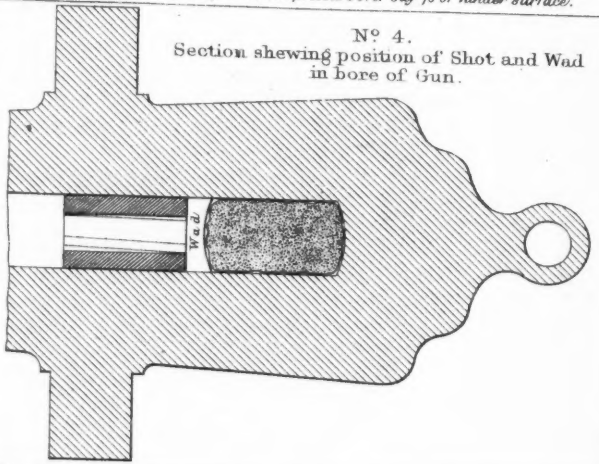
Macintosh Long Range Shot for smooth Bore,
hollow Cylinder internally Rifled,
derives its rotation from air passing through during flight.



Nº 3.



Nº 4.
Section shewing position of Shot and Wad
in bore of Gun.



J. Jobbins.

it, yet there must be even here a serious addition to the impeding forces, in the shape of non-pressure or partial vacuum behind. The value of this has not yet, so far as I am aware, been determined with any accuracy, but it is clearly a retarding force which ought to be eliminated as far as possible. In diagram No. 2 we see the probable aggravation of both these causes of loss of power, air resistance, and non-pressure, as developed in a flat-headed elongated projectile of 640 lbs., but as the velocity will here be considerably lower, it becomes, so far, proportionally less important. Still, however, it cannot fail to be worth close consideration.

We will now turn to diagram No. 3, which represents a projectile of the same exterior diameter, but different in almost every other respect. This is the new form of projectile proposed by the inventor.

You will see by the models on the table that it is hollow and open from end to end—that it is interiorly rifled and that its walls have a thickness of about 3½ inches, which is, however, entirely arbitrary. Its length is 20 inches, the same as that of the flat-headed projectile to which we have been referring, and its diameter is also 12¾ inches. Now supposing this to have been fired from a smooth-bore gun (with a charge nearly equal to what would be used with a round shot), having of course a wad or sabot interposed between the powder and its base, as shewn in diagram No. 4, the passage of this projectile through the air would be as represented in diagram No. 3. The internal rifling is shewn in figures B and C of the same diagram—under two forms, hexagonal and ribbed—but it is even doubtful whether we might not do without any rifling or rotation, and still keep the projectile end on by the rapid passage of air through the hollow centre during flight. However this may be, it is certain that with a mean velocity of near 1,000 feet per second and a consequent mean pressure per square inch of about 58 lbs., there will be ample means of causing rotation; of course there will be the square of the pressure at first while the initial velocity is sustained. Now besides this rotation which, as yet, can only be theoretically asserted to exist with these large shot, but which I can shew you by experiment with a small model, there is the advantage, indicated in diagram No. 3, of the diminution of the retarding forces. About 26 square inches have been taken away from the total resisting surface, and the vacuum behind is also absent to the same extent. In practice perhaps even a less weight, less thickness of wall, and therefore more open space may be often safely allowed. But this projectile, weighing about ¾ths of the 640 lb. flat-headed one, may be fired with a much higher powder charge and will have greater velocity and range, keeping end on, though there be no grooving in the gun and none externally on the shot. There will be also less strain on the gun. It is, however, when we come to consider the application to our old smooth-bored ordnance that the advantages of this invention become most apparent. It is probable that for every rifled gun we have mounted in battery, we have nearly a thousand smooth-bores. Let us take the 68-pr., and particularly the 5 ton solid shot gun. This has

always been highly effective with the old-fashioned shot and shell, still more since hardened shot have been supplied for it. It was no doubt deficient in far-reaching properties, but this projectile would give it a large measure of efficiency at even longer ranges than any rifled gun of equal weight has ever attained. And this, be it recollected, with its lighter sister, is the gun on which our coast defence still mainly depends. At least they would be able to reach the enemy which, as against an enemy with rifled guns, is a hopeless case now. And what numbers of excellent brass field-pieces would find themselves able to compete with the best rifled guns in the field, retaining their magnificent calibre for large round shot, shell, &c., at shorter distances. I shall, of course, be asked what shell it is proposed to use for long range. But to this I am not at liberty at present to reply so fully as I shall be able to do at a later day. The inventor believes that in this form he can produce a shell even more destructive than any that now exist; but whether this be so or not, it is evident that to enable all our old field artillery and all our old iron guns, that are still on the ramparts of many an important possession, behind many a grassy coast defence on our own shores, to enable all these, while retaining all their old powers of offence to fire at least as accurate and as far-ranging a shot as the enemy can bring against them, is not an achievement to be despised or lightly treated. One of the great defects of the whole system of modern rifled artillery, is its utter inefficiency at short ranges. The small diameters of bore which have hitherto been the necessary concomitants of elongated projectiles, making it difficult if not impracticable to get any value out of the canister or grape which is always so formidable a form of missile at close quarters. We do not expect a field-piece, properly so called, to have great powers against armoured ships, but we do require it to possess every known means of annoying uncovered troops; and the power of sending its shot to an immense distance, is, and must always remain a secondary though valuable consideration. Thus for such a purpose it is much better to have a special projectile than a special gun. Then, if we turn to naval guns, what do we find constantly asserted by naval officers—that actions at sea, however they are commenced, must always be decided at short range. There is no doubt whatever in my mind, that whenever a steel smooth-bored gun of large calibre, is fired with a spherical *steel* shot (or one of these new projectiles), and with a powder charge, such as it will then bear with perfect safety, we shall see effects of penetration such as have never been—can never be—obtained from a rifled gun with a shot of equal weight. And if the use of phosphorised copper for field guns can give, as is asserted, equal strength with steel, similar advantages may be there gained while using a metal that can be re-cast with advantage any number of times. Not only so, but our guns might be expected to last very much longer than there is any reason for hoping they may do, under the existing methods of manufacture and grooving.

Whenever the rotation of a heavy body, such as a 600-pr. shot, has to be produced at a high velocity in a short space, no device can ever prevent great strains being incurred in the doing it. Such a case

occurs when we seek to turn a shot by grooves in a rifled gun, of whatever form. Such grooving as Captain Scott's reduces indeed to a minimum these forces, but cannot banish them entirely. And in whatever measure they exist, by so much has the effect sought been diminished, the gun lasting a shorter time, the shot ranging to a less distance. If, therefore, we can accomplish the same object by any change in the form of projectile, even though we find that to take away metal from the centre of the cylinder, is by no means the same thing as taking it from the exterior, as regards diminution of weight, we ought closely to experiment before rejecting an idea which promises such considerable advantages. The experiments hitherto made by Mr. Mackintosh have necessarily been on a small scale. From a smooth-bore musket, charge and other things being equal, he has obtained 300 yards greater range, as much accuracy, and greater penetration, than with the Enfield rifle. He has tried a 6-pr. for penetration with excellent results, but not yet for range and accuracy. It is, however, so easy an experiment, and so inexpensive, requiring only a few shot to be cast for a five ton 68-pr., that I cannot but hope, at an early day, to hear that Government have ordered the trials to be made at Shoebury. Failing this, I believe Mr. Mackintosh will either get some of his friends to make some shot and try them, or, if he can spare the time from his telegraphic and other engineering pursuits, do it himself; but I hope that you will allow I was right in thinking the subject one of sufficient importance and interest, to deserve the efforts I have made to rescue it from the obscurity in which its inventor has for some time past allowed it to slumber.

I have now only, in conclusion, to draw your attention to the fact that this system substitutes a different form of shot for the elongated rifled projectile, capable of giving as little area of resistance to the air, but differently disposed; and that its effect, if thoroughly successful, as I hope it may be, will be to do away with any necessity for rifling, so far as everything except punching armour-plates at long range is concerned. This is one of the least valuable of the qualities of ordnance, if indeed it ever could practically be brought into play, and the gun of the future, must be the strongest, of the largest calibre, not the longest-reaching, of the smallest. I now trust that a discussion on this short paper may give it its value, and with thanks for your patience, have only to express my desire, so far as I am able, to answer whatever questions may be asked on the subject.

Mr. MARRYATT: There is one question I should like to ask. I do not exactly understand how the wad is to act on the shot. It appears to me that when the charge is ignited it will blow the wad into the hollow cylinder and block it up, and perfectly destroy the rotary motion.

Vice-Admiral CODRINGTON, C.B.: There are two questions I should like to ask the lecturer. One is about the penetration. I am satisfied that the penetration caused by a hollow body can never equal the penetration by a solid one—I am speaking now with respect to the penetration of timber or wood. That is one point. The next point is what becomes of the wad? I presume it is a solid metal wad. If so, when the gun is fired, it will be impossible to have troops or friends in advance of the gun. Therefore, I should think it would be rather an impediment to firing in the field.

Rear-Admiral HALSTED: I should like to ask as to the conditions of reality, which at present we have not before us. The merits of the invention are at present assumed. They may become perfectly practical, but at the present moment it is impossible for any person to form any practical judgment upon what will occur upon proof. I quite see the force of the observations which have been made, with regard to the wad, and they are borne out by a circumstance which occurred very recently with regard to the 600-pounder gun. There was a series of experiments made the other day at Shoeburyness with a view of ascertaining whether, from the great diameter of the shot, elongation might not be given to it, as it was not sufficiently long to carry the necessary number of buttons on its jacket to sustain the torsion from the grooves—to elongate it by making the whole rear of the shot hollow. I understand in every case the hollow was blown in by the charge. That mode of elongating shot of large calibre, sufficient to enable it to carry the number of buttons, to give rotation without their being stripped off in the bore of the gun—has failed, so I understand. Therefore the question of the mere piece of wood, as a wad, as I presume it is by its colour on the diagram, has already been put to a proof more critical than it seems capable of sustaining. The whole scheme involves a very serious question—not only of penetration, but, as Captain Selwyn admits, what are we to do for shells? If by this system we cannot use shells, woe betide the ship that can only fire solid shot, while the enemy's ship can return her fire with shell. Mr. Whitworth's 9-inch gun carries a 19 lbs. bursting charge in its shell, and no person having use of such a shell would ever fear solid shot.

Captain HORTON, R.N: I should like to enquire whether, in the experiments for penetration, any observations were made of the rotation of the shot? We see by the model here, how it rotates: but when the shot has passed from the bore of the gun it would be important to know whether it does acquire the rotation that the lecturer says it does.

Dr. CROFTS: May I ask, is the rotation caused by the action of the powder, or is it obtained by the rush of air antagonistic to the bore of the shot?

Mr. LATHAM: I would ask Captain Selwyn whether experiments have been made with these projectiles in a cross wind. I ask this because in some experiments which I made some three years since, with a view to adapting a tubular projectile to the rifle, I found at first that I got very valuable results. I got a much lower trajectory, as evinced by the difference of elevation, of 100 to 400 yards, and I also got increased accuracy. But on sending some projectiles like these in my hand down to be tried at the ranges of the Grenadier Guards, a very curious circumstance occurred. The wind was blowing from right to left across the range, and on the right hand of the target there was another butt, some 30 or 40 yards distant, at which a number of men were at work on repairs. The wind was blowing very strong and gusty from the direction where these men were, and, of course, under the ordinary circumstances of rifle practice you would fancy that nothing could be safer than that. But the men put up the danger signal, as they found the shots were going in their direction. I tried others on the same plan, and I was led to the belief that with any tubular projectile in motion, the air in passing through it acts like a solid body. One fact I am satisfied of is, that these bullets do sometimes turn round and rush along with their noses against the wind; and thus strike in the direction of the wind. The principle of the bullet in my hand is very simple. The rush of air should blow out this plug, the rifling being effected, after expansion, by the grooves of the gun. Of course that makes all the difference.

Captain SELWYN: It does.

Commander COLOMB, R.N.: I think, Captain Selwyn, you were not present the other night when a paper was read on the subject of making elongated shots symmetrical, and placing the centre of gravity exactly in the centre of the figure. We were told that that of itself, without anything else, was sufficient to preserve the parallelism of the axis of the shot. I should like to know whether you agree with that view or not. Then, I should like to ask you, whether it is not the case that shot have been tried with outside grooving, to be acted upon by the air in the same manner as this inside groove is? and whether those experiments were successful or not? If

unsuccessful, on what ground should you suppose that the inside grooving would answer where the outside grooving failed?

Captain FIELD: I do not wish to say one word in disparagement of the idea submitted to us. Perhaps the lecturer is aware that the idea is not altogether a novel one; that experiments were tried with smooth-bore round shots some years ago on board the "Excellent," by having three holes placed at certain angles for the air to pass through, as the shot was driven by the charge. Certain experiments were carried out on board the "Excellent," in my own presence, and on that occasion the experiments failed. Still this plan, of course, is different, inasmuch as we have an elongated body.

Captain SELWYN: I may say that I was pretty nearly prepared for every objection I have heard here, except that of Admiral Halsted's, which I will take in its turn. With regard to the first question, as to the wad being blown through the projectile, engineers are perfectly aware that, given any percussive force, they have only to test their material, and to adapt it to the circumstances, and then they will produce the effect. If you look at this model of the 68-pounder you will see the bearing surface of the wad here. It may be made of steel, if you please; it may be made of any possible metal or substance—from Bielfield's material, which is made of fibre compressed—up to steel. There is not the smallest objection to it, as I will show presently, with regard to the troops in the front. Such pressure can never force a wad through, or do much to cut the wad. It will not force it through in any way, even if no thicker than one inch; but if you found it did force the wad through, being one inch in thickness, you have only to make the wad two or three inches thick. There is no possible objection to it, for long range work, such as that. With regard to the penetration of timber or wood it is evident that the penetration of all bodies, subject to the impact of what may be regarded as a punch, is strictly proportioned to the resistance to crushing pressure, due to the velocity first, and to the weight second, disposed on the area with which impact is effected; that is to say, that if the penetration is to be effected with the whole surface of the old projectile, a surface, say, of eighty square inches, if it be necessary to employ 100 lb. on the square inch, to enable that surface to pierce pine, oak, or anything you please, there will be so much the less power required to effect the same penetration with this shot, because you have diminished the number of square inches over which the impact takes place. That is familiarly known in the way of punching boiler plates, and other materials which are now extensively subjected to such engineering processes, and we never fail to find that those laws are absolutely and mathematically true. With regard to what becomes of the wad, the wad very naturally falls off. It is not attached in any way to the shot, and it is not capable of penetrating; it falls off. But it is not proposed to use these projectiles for anything but long range, and as troops would be very unwisely stationed in front of guns fired at long range, and as they never need be so, there is not much fear as to the falling of the wad among them. At sea still less, for if the wad falls into the water, and the shot goes to the enemy, you may be quite content with the effect produced. With regard to Admiral Halsted's objection, it is one of the last I should have expected to hear from him. It is in effect that we ought never to believe anything until we have seen it tried—until we know it is right. In fact, we are not to theorise at all, but we are to wait until everyone knows that a certain effect has been produced before we say, "Excellently well done. This is the right thing; we all know it." I am afraid that if Mr. Whitworth remains contented till that occurs, we shall not see his system go forward, as no doubt it is Admiral Halsted's desire that it should. With regard to the blowing in of the rear end of an Armstrong shell which he alluded to, it was desired to increase the number of buttons in order to obtain the bearing surface, which, unless my engineering knowledge very much deceives me, might have been obtained equally well by resorting to that system of ribbing, as in Captain Scott's projectile, which gives the bearing surface without elongating the shot. With regard to that, I have merely to say that the same law applies to it that applies to the wad. If you make the base of your shot so thin that it cannot resist the crushing pressure brought upon it by the explosion of the powder—13 tons to the square inch before the projectile can be set in motion—then you may expect your shot to be crushed. I should recommend anyone to make the shot a little thicker in

the base, and to try more experiments as to the amount of pressure which iron or steel will sustain before he puts a shot into the gun. As to the shell which Admiral Halsted also referred to, I think he misunderstood what I said. I said that the inventor was preparing a shell, but that he did not wish, at present, to make it known; that he was perfectly confident that he could make a better shell, and a more destructive one, than you have ever had before. Therefore, it is not fair to assume that I have said there is no shell for the gun.

Admiral HALSTED: I beg to say that I said no such thing. I said that until we have the whole thing before us it is only assumption.

Captain SELWYN: The rotation is accomplished entirely by the air force overcome, which must be overcome in all cases. But it is the great difference here, that that force is expended usefully instead of uselessly. It is expended in producing that rotation, which you otherwise have to gain by the strain thrown on the gun, and instead of being expended in retarding the flight of the shot. It is not in any way affected by the explosion of the powder in the gun, which has no other office, and which should have no other office, than to project the shot with the greatest attainable velocity. With regard to the effect of a cross wind, a wind up and down the range, that will be a quantity dependent entirely on the velocity with which the projectile is caused to fly. If, unnecessarily or unwisely, you put the shot into a rifled gun, and thereby obtain, by detention in the gun, a lower velocity, then you will have brought into play one of the opposing forces, which will very likely cause any error you please. But I do not think any experiments tried by one person, which have been a success, should be contrasted with experiments made by another person, which have wanted success, especially when one of the conditions has not been observed. With regard to the symmetrical shot, or rather a shot which has a properly disposed weight; although I had not the pleasure of being present, my attention has been long ago turned to the subject by the gentlemen who have advocated that principle. I have only to say, in answer to the question, that although it does attain the object sought, as I said in my paper, that of causing a shot to go end foremost, without rotating, yet it does not obtain that which we seek also; first of all, great calibre, then the power of firing all projectiles of whatever nature, and the power of firing exceptionally long range shot. This system of hollow projectile leaves the question of calibre and the question of disposal of weight exactly where they were before. The shot is no greater in diameter, it is not incapable of being fired with a higher powder charge, nor does it throw more strain on the gun, inasmuch as the rotation is not accomplished by grooves. They are, necessarily, expensive projectiles,* because they have to be made with the care which the shot which you are going to throw at your enemy ought to receive. The outside grooving, which I am also aware has been extensively tried, and, at first, with some little success, is liable to objections on account of the very fact which has been referred to, of the wind blowing across the range. The velocity there only accomplishes the rotation by means of the currents of air striking on the outside of an exposed surface, not confined inside the shot as in this instance, where the hollow shot may be said to run on a rod of air, whether it be rifled or smooth. But other opposing currents striking, as in cross winds, or opposing vanes or ribs, and thus giving partial rotation, are always liable to produce error in flight. The round shot with holes is an experiment which has been tried. I have not, I confess, seen the experiment, but it will be obvious to any one who will consider the way in which the shot shown in No. 1 diagram, issues from the gun; a spherical shot rolling along the lower surface of the bore of the gun, setting itself in rotation in exactly the opposite sense to that in which the rifled shot rotates, that is to say, the axis of which is at right angles to the bore of the gun; if you put holes in it the effect of those holes will be, that they will turn about, either to the rear or to the side, just as the disposal of weight incident to the boring out of a certain proportion of the metal may influence it. I should say that they would probably produce a much less correct flight than would be obtained with the ordinary spherical shot, made as homogeneous as possible. I think that I have now answered, so far as I am able, all the objections which I have had the pleasure of hearing; and if I have done

* Price is £10 per ton.

so feebly, I can only regret that the subject has so bad an advocate. I have to say, in conclusion, that it is folly in any Institution, to put down any theory, or to say it is not worth examination, till you can show its advantages are *nil*. If the plan proposed has such advantages as those I have had the pleasure of stating to you, then, I think, the least we can do is to examine and try all things, and to hold fast to that which is good.

Captain HORTON: I am afraid that Captain Selwyn did not quite understand me. My question was whether it had been ascertained by any experiments that the projectile acquires that rotation in its flight.

Captain SELWYN: An experiment tried with a smooth-bore musket, and with a six-pounder, gave evidence of the punching out of clean, bright, sharp holes, having traces of the spiral action of the projectile through its flight.

The CHAIRMAN: As Chairman I will say nothing myself, but simply direct your attention to the wide range of subjects which is taken in hand by this Institution. It was only three nights ago that I was addressing you on the subject of the preservation of life, and here is my friend, Captain Selwyn, addressing us on the subject of the destruction of life. I am sure you will allow me to convey our thanks to Captain Selwyn for the valuable paper he has read.

Evening Meeting.

Monday, May 14th, 1866.

VICE-ADMIRAL H. J. CODRINGTON, C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 7th and 14th May, 1866.

ANNUAL.

Abbott, Saunders A., Major-Gen. Bengal Army. 1*l.*

Purcell, Edward, Admiral. 1*l.*

Steward, E. Harding, Capt. R.E. 1*l.*

TORPEDO DEFENCES.

By NATHANIEL J. HOLMES, Esq. E.E.

THE subject of the present paper is that of the construction and use of the electric torpedo as a means of defence against the approach of an enemy by land or by sea.

Henceforth the torpedo is entitled to rank as one of the most terrible and deadly weapons of warfare that exists, and one that science enables to be accurately and surely manipulated, and which, in the hands of the naval and military engineer, when properly constructed and placed, will constitute a defence against which both rifle guns and iron-clads are powerless for attack.

The important aid that electrical science can render towards a successful issue of arms is very forcibly illustrated by two incidents in the late American struggle.

On a certain day in the year 1864, General Grant assembled his forces before Petersburgh, and he had planned that the assault on that city should take place at two o'clock in the morning, immediately following the springing of a mine laid and calculated to explode at that hour. This mine did not explode as arranged, and the ignition did not take place until some hours afterwards. General Grant's plans were foiled, and Petersburgh was saved.

To the non-explosion of this mine may be attributed the failure of that assault. Had this mine been properly laid and sprung by electricity, the precise hour, the minute, nay the very second, of its ignition could have been determined, and this mishap prevented, involving as it did the disgrace of failure.

Again, on a certain day in the year 1864, the Federal fleet passed up the James River, the channel way of which was mined with electrical torpedoes. The defence of the first passage was entrusted to a single torpedo placed in mid-channel. The ignition of this torpedo, unlike the mine before mentioned, was arranged to take place by electrical agency, and to be exploded even to the precise second of time required at the will of the operator.

Few illustrations can be more instructive to show the value of the electric torpedo, and the deadly nature of its effects, than the narrative of the springing of this mine. The officer in charge of the electric wires was concealed a few yards from the edge of the river bank, sufficiently near to distinguish the voices of the officers and crew upon the deck of the steamer, the advancing vessel of the fleet, carrying five guns and 120 men.

By previous arrangement it was determined to reserve this mine for the admiral's ship; the steamer was, therefore, allowed to pass up the stream unharmed, in advance of the admiral. The officer in charge of the mine hearing, however, the order given to fall back and send out the boats to drag for torpedoes, determined to hoist her as she passed down to rejoin the fleet.

The explosion took place on a clear afternoon, and was witnessed by many persons. The boilers, engines, and smoke stack went up about 20 or 30 feet, the boilers bursting at the same time, and the hull of the vessel was shattered to fragments. Strange to say, three of her people escaped alive.

It is worthy of remark that the position and ignition of this single torpedo gave rise to the construction of the "Dutch Gap Canal," and delayed the advance of the Federal fleet for a whole week.

This example will illustrate the value of properly applied torpedo defences; but before proceeding to details, it is as well to strengthen this remark by an extract from the report of the United States' Naval Secretary, dated December, 1865:—

"Last April the United States fleet attacked and passed the heavy "forts erected for the sea defences of Mobile, mounting nearly four "hundred guns, all of which were captured, some of them being rifled, "and of the heaviest calibre. In January the most powerful fleet the "United States ever assembled, consisting of fifty-eight vessels, many "of them iron-clads, and all of them the most formidable of their class, "attacked and carried the forts and batteries erected for the defence "of the approaches of Wilmington from the sea. Here two hundred "and ten guns were captured, some of them superb rifled pieces.

"The only vessels lost by the United States Government in both "these attacks, and the shore batteries of the Confederates were "splendidly served, were destroyed by *electric torpedoes*, which, always "formidable in harbours and internal waters, have proved *more* "destructive to our naval vessels than *all other means combined*."

The perfect development of the torpedo as a weapon of defence has been necessarily gradual.

In 1854, during the Crimean war, the Russians employed mechanical torpedoes against the British fleet in the Baltic.

These missiles were contrived by Professor Jacobi, and consisted of inverted hollow conical vessels, filled with powder. The mechanical arrangements for igniting the charge were brought into play by percussion, the impact of the torpedo in striking the ship breaking a tube containing sulphuric acid over a mixture of chloride of potash and sugar, and thus inflaming the charge. Torpedoes of this construction might prove equally dangerous to friend as to foe. Fortunately, they caused no damage to the British fleet. This class of mechanical torpedo is, however, open to very grave objections, for should they remain immersed any length of time in the water great uncertainty of action must arise from rust and incrustations taking place externally.

The next advance in the use of torpedoes was made by the Austrians at the time of the threatened attack on Venice by the French in 1859. Here Baron Ebner employed them to defend several of the more important channels, and organised a very elaborate and well-considered plan of defence.

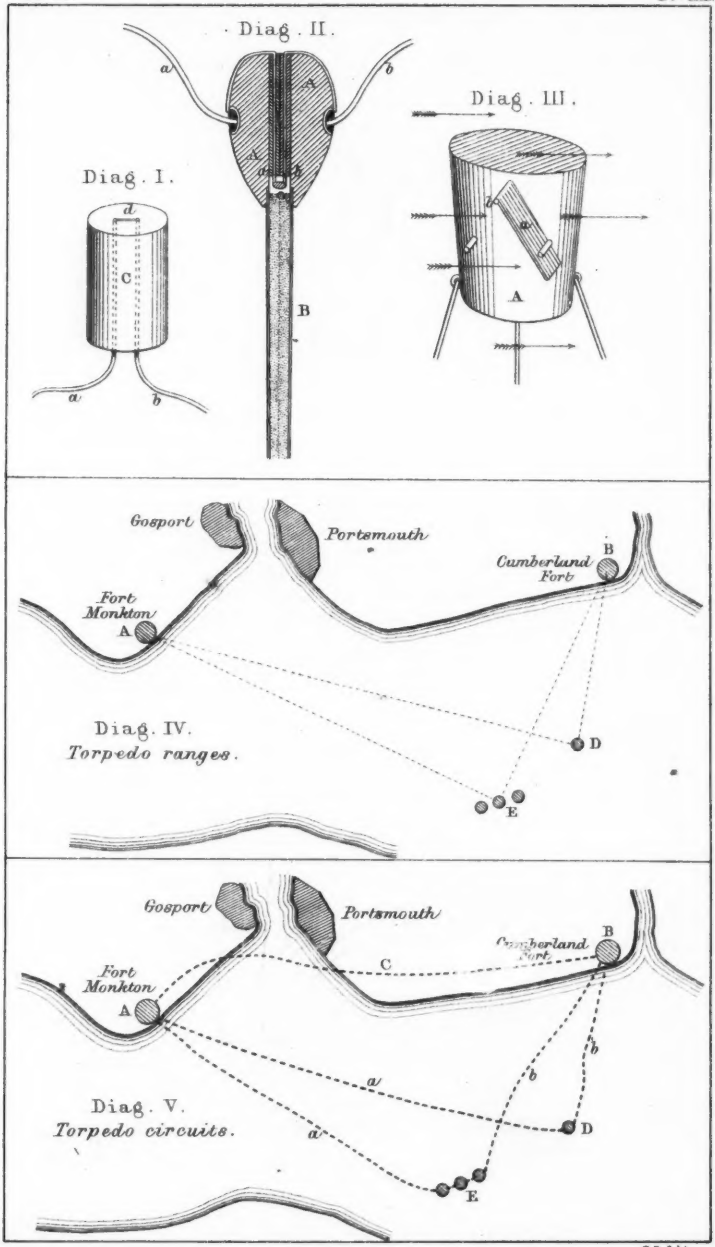
These torpedoes were arranged to explode by electricity. A system of insulated electric wires, which extended from the shore to each torpedo, placed them under the control of the operator. In planting these torpedoes their positions were registered upon a miniature plan of the harbour, by a very ingenious application of the camera-obscura. By this device it became unnecessary to mark the positions by buoys.

The knowledge possessed at that time did not permit of Baron Ebner applying any direct test through his torpedo mines to determine the integrity of their condition, as well as the continuity of the several circuits. He, therefore, employed an independent wire to pass his test currents, but which formed no part of the torpedo circuit. The armistice that followed prevented the completion of these proposed torpedo defences, and the few that were actually laid down were removed.

To the late Confederate States Government and Captain M. F. Maury, the deep sea hydrographer, is due the merit of having practically employed the torpedo with success for harbour and channel defences, and these results, now a matter of history, have proved that even in its then imperfect condition it was destined to play a most important part in the fortunes of that war.

In the never ending contest of the present day between the penetration powers of rifled guns against the penetrability of armour-clad ships, massive fabrics have been constructed at great cost and expenditure of labour, and without any very definite notion as to whether the balance of power remains in favour of the rifled gun or the iron-clad. With the torpedo this competition ceases. Simple in its construction and action, called upon to expend its power upon the enemy without reciprocal challenge, the most formidable armour-plated ship, with its complement of rifled guns, is, without warning, in a moment, stricken in the most vital part by this hidden monster, and if not totally destroyed, at least fatally crippled.

Before any system of torpedo defence can be considered perfect and reliable, the following essential conditions require to be fulfilled:—


Diag. II.
a
b
A
A
A
a
b
B
Diag. III.
a
A
Diag. I.
d
C
a
b
Gosport
Portsmouth
Cumberland Fort
B
Fort Monkton
A
D
E
Diag. IV.
Torpedo ranges.
Gosport
Portsmouth
Cumberland Fort
B
C
Fort Monkton
A
a
a
b
b
D
E
Diag. V.
Torpedo circuits.

J Jobbins

First. The torpedoes in themselves must be non-explosive and harmless, not liable to accidental discharge by percussion or carelessness.

Second. The power of testing at all times the submarine or land circuits of the torpedoes without danger of explosion, and of speaking and telegraphing information and instructions through the charge without risk.

Third. The power of igniting the mines at will, and of discharging several torpedoes in group with a single wire at distances exceeding that of the range of artillery, and that the explosion shall only take place when the vessel to be destroyed is within the area of destruction.

Fourth. The power of discharging the mines, even should the enemy succeed in breaking the conducting wire, and of preventing the explosion of the mine by the enemy, should the wire fall into his hands.

In proceeding to describe the principles and combinations of parts by which these important results are obtained, it must be borne in mind that hitherto the enquiry into the use of the torpedo has chiefly been conducted in secret, and the progress made has not been published. The system under consideration has been the result of private experiment and investigation by Captain Maury and myself, and for which a patent has been granted as far as regards the combination of parts, and principles necessary for the arrangement of the circuits, testing, and ignition of the torpedo mines.

The torpedo in its complete form consists of three parts, the fuze, the charge, and the torpedo case or tank, together with the necessary internal and external arrangement of electric connections, and conductors, giving the operator the entire control over the mine.

The Fuze.—Various forms of fuzes exist that may be ignited by electricity. They may be divided into two classes, the simple, and the chemical fuze.

The simple fuze in principle depends upon the introduction within the fuze arrangement of an imperfect conductor as part of the circuit. The increased resistance thus formed to the passage of currents of high intensity heats this substance to incandescence, and so ignites the powder. Thus plumbago (black-lead) which is comparatively an indifferent conductor as compared to metal, will, under certain conditions, on the passage of an intensity current through its circuit, burn and throw off incandescent particles sufficient to ignite gunpowder. Fuses may readily be constructed upon this principle.

The ends of the two conducting wires *a* and *b*, diagram i, Plate xx., are inserted through a small cylinder of wood *c* (the grain running parallel to the wires), say a quarter of an inch apart, and the ends adjusted so as to be level with the surface of the wood. Now if the circuit between the ends of these two wires be completed by drawing with a black-lead pencil a mark *d* across the intervening space, upon passing a strong current, the plumbago will inflame and ignite gunpowder. Another form of the simple fuze consists in winding a piece of linen tape previously smeared over with pure carbon (lamp-black) round one end of the conducting wire, the return circuit being formed by one or two twists

of a piece of fine wire round the tape and on to the other end of the conducting wire. Upon passing a current, the circuit being completed through the carbon cloth, it will burn and ignite powder.

In practice, fuzes of this nature are objectionable, inasmuch as they cannot be implicitly relied upon, the plumbago or carbon offering such varied resistances and conducting powers, that test currents might at times prove dangerous as igniting currents.

The ignition of such fuzes is also slow and uncertain as compared with the chemical fuze, they are, therefore, not sufficiently under the control of the operator. The chemical fuze, as prepared by Mr. Abel, the Government chemist at Woolwich, may be considered absolutely certain and instantaneous in its action, the ignition being perfectly under control. Such, however, is the perfection to which chemistry has arrived, that when the conditions to be fulfilled are known, there is little difficulty in obtaining the necessary combinations, and various other sensitive chemical compounds are known which may likewise be employed for this purpose.

The fuze that best fulfils the required conditions, is that known as "Abel's," fuse, the component parts of which may be taken as consisting of—

Subsulphuret of copper	64 parts	100 parts.
Chlorate of potash	22 „	
Subphosphuret of copper ..	14 „	

The construction of this fuze is simple. The two ends of the conducting wires *a* and *b*, diagram ii, carefully insulated from contact with each other, are passed through a wooden head-piece, A, so that the two ends slightly project, about the $\frac{1}{40}$th of an inch apart. Upon these projecting extremities a small quantity (from $\frac{1}{3}$ to $\frac{1}{2}$ a grain) of the fulminating mixture, *c*, is placed. This is afterwards capped by a quill or tube, B, containing meal-powder, fixed securely into the wooden head. The detonation of the compound on the passage of the electric spark ignites the powder and inflames the mine.

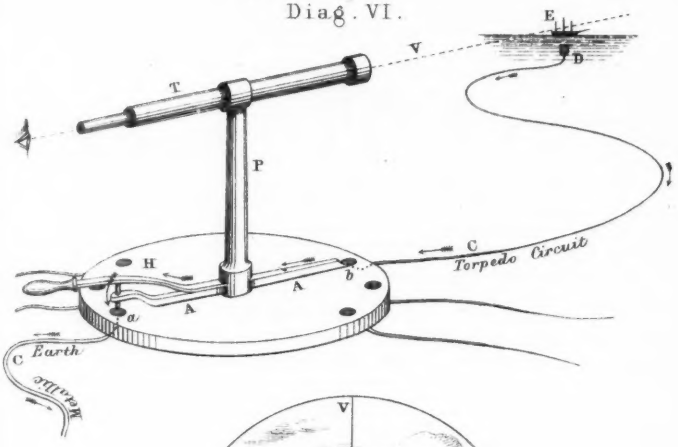
The quantity of powder placed within the mine must depend upon the conditions of the attack and the effect to be produced. Hitherto this amount has depended very much upon the impressions that the operator entertained regarding the explosion of powder under water. In determining the charge to be used, the area of destruction, and the depth of water intervening between the torpedo and the ship must be carefully considered.

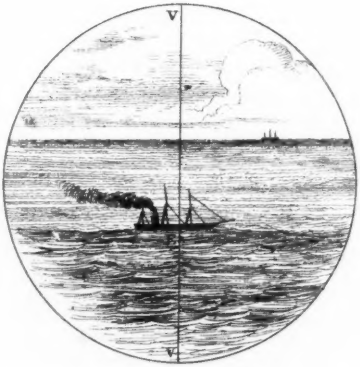
When a torpedo is exploded under water, the co-efficient of force may be represented by a cone, the apex of which lies in the line of maximum power, and path of least resistance, and the area of destruction of which will be the plane formed by the intersection of this cone, and the surface of the water. The maximum area of destruction of a torpedo is therefore attained when the resistance of the water, as compared to the power of the charge, is such that the base of the cone is nearly at the surface.

When the depth of the water cushion is not calculated in proportion to the power of the charge, the apex of the cone will fall beneath the

TORPEDO DEFENCES.

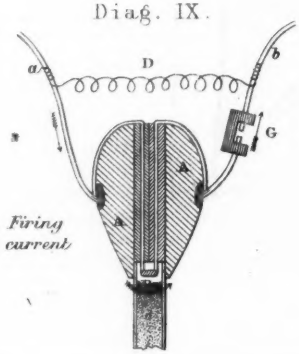
Diag. VI.



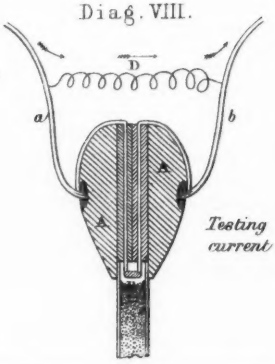


Diag. VII.

Diag. IX.



Diag. VIII.



J. Jobbins.

surface, and no effect of importance will be produced. The deeper the torpedo, with a given charge of powder, is sunk below the surface, the more depressed will be the apex of the cone, until at last it resolves itself into a spherical form; and if the torpedo is sufficiently near the bottom, the explosive force will be expended in vibrations through the ground. One or two instances of this nature have occurred. Last year Admiral Vicomte de Chabannes was experimenting upon the explosive force of given charges of powder at various depths, and in one of his experiments, in which he had not properly proportioned the charge to the resistance (namely, twelve pounds of powder and a water cushion of thirty feet), the force of the explosion was expended through the ground, and communicated to the piles of the pier at Toulon where the spectators were assembled, while the surface of the water remained comparatively undisturbed. A similar instance occurred to the Confederate engineers in exploding one of their experimental torpedoes, the depth of water proved too great in proportion to the charge, and the firing party on the shore were knocked down by their own mine.

Accurate experiments are still wanting to determine these important data, the charge of powder in relation to the water cushion.

These few general remarks upon the effects of exploding powder under water are sufficient to explain the reason of the pagoda-like form that water assumes when forced into the air by a subaqueous explosion. The pinnacle of the pagoda represents the apex of the cone, and the successive steps of the column the co-efficient of force determined in relation to the resistance of the water and lifting power of the charge.

The displacement of the torpedo tank or case requires to be regulated according to the nature of the defence, that is, whether the mines are constructed as "*floating*" or "*ground*" torpedoes. The "ground" torpedo requires weight to lie solidly on the bed of the channel; it is not necessarily provided with any amount of air-chambers. The tank is simply water-tight, and fitted with properly constructed openings and joints for the introduction of the charge, fuse arrangements, and conducting wires. The "floating" torpedo requires buoyancy, therefore the displacement of the tank must be calculated with reference to its required ascending power. Torpedoes of this description are anchored in position with tackle and guys of the requisite length and strength.

To prevent the position of the torpedo being interfered with by currents and tides, two moveable fans, *a a*, figure 3, are attached to the sides of the tank. These, by the motion of the stream working on their pivot bearings, *b b*, become inclined planes against which the horizontal pressure of the current is converted into a vertical ascending force, raising the torpedo A into position in the same manner that a kite is elevated by the action of the wind.

The important details connected with the electric circuits, laying down, testing, and ignition of the mines, will be illustrated by reference to diagrams iv. and v., supposed to represent the entrance to Portsmouth harbour. At each of the two forts A and B, diagram iv., on either

side of the harbour, observers are stationed with telescopic apparatus. In these instruments, figure 6, Plate xxi., the telescopes T are fixed upon vertical pivots P, which, moving only in the horizontal plane, sweep the horizon and ocean at a certain elevation. To the axis of each of these telescopes, and moving in the same plane, an arm, A, is attached, and which will therefore complete the circuit between any two points over which its extremities *a* and *b* may pass at the same instant of time. The handle, H, is a mechanical arrangement for completing the circuit *c c* at the precise moment of time that the enemy, E, passes the range in the field of vision V, figure 7.

Such being the outline of the mechanical arrangements at each of the observing stations A and B, diagram iv, the torpedo is taken out in the boat, and at the moment of submersion the angular bearing of the position D is accurately registered by each of the observers at A and B.

When, therefore, in observing the movements of an enemy, either telescope, in sweeping the horizon, strikes that angle, it is in range with that mine or group of mines. The same process is observed with reference to the submersion of each successive torpedo, the exact position of which can be at any moment determined by the coincidence of cross bearings similar to A D and B D from the two stations at A and B.

The introduction of additional observing stations is frequently of great importance to the security of the torpedo defence. By such a system the ignition of the mines are not left entirely dependent upon the concurrent observations of any one station. In the event of that station either falling into the enemy's hands or otherwise being abandoned, the bearings of the torpedoes can then be determined, and the circuits closed with equal precision by observation from another station.

The arrangement of the submarine and land conducting wires are of great importance, and the greatest precaution is necessary to protect them from the possibility of injury from lightning, causing the accidental explosion of the mines, as well as derangement from other causes.

All land wires in connection with torpedo defences should be concealed, and buried in the ground at a sufficient depth to prevent injury or discovery by the enemy. The submarine wires in the same manner should also, whenever practicable, be carried under ground from low-water mark into the observing and igniting stations. Damage from lightning is thus avoided, and the enemy have no clue to the position of the circuits. All the apparatus employed for observation, and the discharge of the mines, should likewise be constructed of materials other than metal, which being a conductor and liable to produce accidental contacts, should be introduced into the combination of parts only in the most sparing manner; nothing but the circuit conductors in connection with the torpedoes should be permitted to enter the apparatus and observation-rooms. With precautions such as these in the construction and arrangement of the circuits and apparatus, all danger is removed, and accidents become impossible even in the hands of inexperienced officers.

The importance of maintaining independent telegraphic communication between the several outlying stations and the centre of action is so great, that a distinct metallic circuit C, diagram v., should be employed to test and ignite the mines. This wire, which takes the place of the return circuit through the earth, enables the testing operations to be carried on with very great nicety, a leak or break in the conductor being at once detected from the known and constant resistance of the circuits.

The conducting wires, *a* and *b*, from the torpedo, D, are indicated by the dotted lines as being carried into each of the observing stations, A and B. It thus follows that whenever the circuits at those stations are closed by means of the handle, H, attached to the observing instrument before described, diagram vi, a complete circuit is established through the torpedo, D, and the metallic earth, C, discharging the mine. For each distinct torpedo, or group of torpedoes, E, the connections are in the same manner carried into the stations A, B, and are under the control of the observers for the completion of the circuits, so soon as the enemy is within range of their respective angular bearings A E and B E.

The power of testing the effective condition of the circuits and connections within the torpedoes, and of speaking through the mines with intensity currents without danger of ignition, constitutes one of the important features of the present system, and one which has more than any other contributed to inspire that confidence in the submarine torpedo which the value of the invention demands.

When currents of low tension are employed (supposing the construction of the fuse to admit of imperfect conduction), the tests as regards the circuit conductors and internal arrangements of the torpedo cannot be regarded as satisfactory. Terrestrial induced currents frequently interfere with the integrity of the results.

The difficulty of accurately testing the mines after submersion, in order to ascertain the correctness of the connections, has always constituted one of the great obstacles to the successful employment of the torpedo under water. The moment that a test current of any strength was passed through the mine an explosion followed. From this cause the torpedo defence, up to the beginning of the year 1864, was regarded with doubt and uncertainty, no proper system of testing having been established to determine the effective condition of the wires and connections for exploding the mine. The investigations of Captain M. F. Maury and myself have, however, entirely overcome this serious difficulty, and now, under the new system, the torpedo mine may be fearlessly and harmlessly tested by powerful intensity currents with perfect immunity to danger. The same apparatus that previously exploded the mine will now have no effect upon the fuse, save the passing through the circuit conductors, and internal fuse connections of the torpedo, currents of sufficient intensity to indicate the integrity of every connection, and enable the employment of suitable apparatus for the purpose of telegraphing through the mines from station to station.

The importance of this result cannot be over-estimated when the

value of telegraphic communication in active service is considered. The experience of the recent victories by the Prussian armies in Bohemia over the Austrians, points to the great importance of maintaining telegraphic communication between the outposts, stations, and outlying divisions of the army in regulating the successful issue of their military manœuvres, and the same rule equally applies to naval tactics. For instance, let it be supposed that the enemy's fleet is advancing up channel; with this system, orders could be immediately transmitted from A to B directing attention to such and such a vessel, or the intended discharge of such and such a group of mines, under certain instructions to be given during the progress of the attack, or the emergencies of the moment, and the transmission of such intelligence, while it places the whole field under the control of the commanding officers, at the same time points out the integrity of the several electric circuits.

The instruments best adapted for both the testing and speaking arrangements are the small portable magneto-alphabetical telegraphs of Professor Wheatstone. These instruments require no battery, are always ready for immediate use without previous preparation, are simple and easy to read, and sufficiently powerful to work through circuits of 200 miles in length.

[At the request of Mr. Holmes, an Officer, acquainted with the manipulating of Wheatstone's telegraph, came forward and took his station at one battery, which was made to represent Fort A. From this battery wires were passed through a torpedo suspended over the table, and thence to another battery representing Fort B, where Mr. Holmes took his station. A message written by the Chairman, "How many men have you?" was handed to the first gentleman, and by him transmitted from Fort A through the torpedo to Mr. Holmes at Fort B, by whom it was read off, word for word, as fast as it was received.]

The great value of this feature in the system is this, that you not only find out that the wires connected with the torpedo are in proper working order, but that the observers at the two stations, A and B, can communicate with each other through the torpedo, and concert measures against the enemy. For instance, should A say to B, "We will let the four first vessels pass, and blow up the steamer and the last vessel;" the four first vessels would be allowed to pass, and when the steamer and the last vessel were blown up the enemy would find they were in a trap, and would not be likely to go any further. This Wheatstone's Exploder I used at the Edinburgh Observatory, to fire the time gun at Newcastle-on-Tyne, a distance of 120 miles. I passed the current along the wires of the International Company; and every day this machine fired that gun. Therefore, you have some notion of the power of this machine. I will now pass a current from this machine, also harmlessly through the mine; because what I wish to illustrate to-night is, that upon this system your mines are perfectly safe; there is no fear of accidental explosion—unless the rules are really unobserved there can be no risk of accidental explosion.

In explaining the principles by which this testing and telegraphing

is harmlessly carried on through the mine, it is necessary to draw attention to the fact that in order to pass a current of electricity in any required direction, a metallic or other conducting path must be prepared for its reception. In the construction of the fuze-head, diagram viii., the metallic circuit of the conducting wires *aa*, *bb*, is divided at A, interrupting the direct metallic path of any current passing from *a* to *b*. In contact with the extremities of these wires is placed the fulminating mixture B.

This compound, although it conducts sufficiently to admit the passage of weak voltaic currents for short circuit tests, to determine the integrity of the fuze before it is allowed to be used in the torpedo tank as the igniter of the charge, will from its resistance explode the moment an intensity current is passed through. A metallic bridge, D, has therefore been introduced to afford a direct path to the intensity current in the direction *a*, D, *b*, cutting out the fulminating compound at B.

This metallic bridge is composed of fine platinum wire ·005 of an inch, not so thick as a hair, and the short length employed offers little resistance as compared with the rest of the circuit wires. Three feet of this fine wire may be taken roughly as representing a resistance equivalent to a length of one mile of the submarine conductor.

By this metallic bridge the testing and telegraphing currents are passed harmlessly through the torpedo and charge, along the conducting-wires from station to station. In order the more effectually to guard against the possibility of danger or accidental explosion of the mine during the process of testing and telegraphing through the charge, a broken circuit is interposed between one extremity of the "bridge" D, diagram ix., and the fuze, cutting off all communication with the detonating compound at B.

It might arise that the resistance of the "bridge," D, was so nearly equivalent to that offered by the imperfect conduction of the fulminating compound at B, that a divided circuit might arise sufficient to explode the mine.

This broken circuit, or "gulf," is shown at G.

By means of this broken circuit the passage of all intensity currents are absolutely interrupted, and all danger of divided currents avoided. The proper length of the wire composing the "bridge" is determined by experiment, and it has relation to the resistance of the circuits and number of torpedoes to be ignited in the same circuit. These resistances being known and reducible to rule the igniting charge of the torpedo, that is, the fuze-bridge, gulf, and primer, can be properly prepared and supplied ready for insertion into the torpedo-tank, according to the size and other conditions of the mine.

We all know in gunnery, when you talk of a 68-pounder, you have shot and shell ready prepared; you have nothing to do but to put the shot or shell into the gun and ignite the charge of powder. So with the torpedo, it is now reduced to such a system, that if you wanted to discharge a torpedo at five miles, or ten torpedoes in a group with a single wire, or three torpedoes in a group with a single wire, or one torpedo, or any number, you have the particular igniting charge ready

made; you have nothing to do but to put it into the case and seal it up. These igniting charges are simply cylinders properly insulated with two conducting wires that come out; they contain the fuze, the bridge, and the igniting charge; you drop them into the mine like an Armstrong fuze into a shell. They can now be constructed with all the mathematical conditions that are required.

The ignition of the mine has next to be considered, and upon the certainty and accuracy of this operation depends entirely the value of the electric torpedo as a means of defence. Delay or doubt for a moment upon this point might prove fatal to the prospects of victory.

The importance of this accuracy and precision of ignition will be understood by calculating the length of time the enemy remains in the line of vision. A vessel steaming, say at the rate of nine knots an hour, will move through the water at the rate of 18 feet per second, and supposing her length to be 300 feet, she will remain in position to receive the effects of the blow only 16 seconds, scarcely a quarter of a minute. The velocity with which electricity travels is so great, that the length of the torpedo circuits form no impediment to the instantaneous discharge of the mine if the firing arrangements are properly carried out. At the time that I carried out the experiments in 1863 of firing the "time-gun" at Newcastle-on-Tyne by a spark passed from the clock of the Royal Observatory, Calton Hill, Edinburgh, a distance of 120 miles, the interval of time between the passing of the Edinburgh current and the actual ignition of the charge in the gun was measured to within a fraction to represent the $\frac{1}{10}$th of a second.

A simple mode of completing the igniting circuits at the observing stations, A and B, with those of the torpedo is illustrated in diagram vi., and the coincidence of the enemy with the line of vision is represented by the view to the observer's eye through the field of the telescope, diagram vii. In determining the coincidence of the enemy's range with that of the mine by the observers at A and B, the circuits mechanically adjust themselves so that upon the instant of depression of the handle, H, the current passes and the mine explodes.

What I mean by the line of vision is this. The diagram vii. represents a view to the observer's eye, looking through that telescope. He is looking out to sea, the axis of vision of the telescope being in the line to the torpedo at sea. Across the field of the telescope he has a wire V, and that wire is the range within which the observer knows one of the torpedoes are planted. Therefore, whenever he turns his telescope so that it falls into any one of the angles previously noted, this line is identically in the centre of the torpedo. When, therefore, any vessel crosses that line she is in the range of the torpedo, as far as that observer is concerned. But, of course, looking through this telescope, it is impossible for him to say whether the torpedo is half a mile on the far side, or half a mile on the near side of that ship. All he is able to determine is that crossing his wire she is in range of the torpedo; she may be either over it, or beyond, or near it. But the concurrent observation of the next observer through his telescope accurately defines the exact position and moment

when she is over the torpedo; consequently, between the two ranges, at the intersection of the angles, whenever a ship happens to be at that particular point, she must be over the torpedo, and if the charge is fired she must go up—the mine must explode. If she is not over that mine, although this observer may attempt to fire his charge, it is a broken circuit, and the current cannot pass, because he only registered the vessel in that direction, when she is in the line with the torpedo; and unless she is in the line with the torpedo on both ranges, the circuits of the torpedo will not be closed by that bridge piece at the bottom of the telescopes. Now, in this view she is represented as being in line with both ranges of vision; therefore, the torpedo wire is bridged over to the igniting wire, and the moment that handle is depressed, the contact is made, and up goes the mine.

The electricity employed for the ignition of the mines is essentially different in its effects to that used for the testing. The "intensity" or testing current as already explained passes by the metallic bridge in preference to taking the circuit through the fuze and gulf. It is, therefore, necessary that the electricity employed to ignite the mine should select the other path, passing by the fuze and gulf, and not through the metallic circuit of the bridge. This is effected by employing currents of accumulated electricity for the ignition of the mine. Electricity of this nature prefers to pass the fuze and leap the gulf, rather than force its way through the resistance of the fine wire composing the metallic circuit of the bridge, and which offers almost infinite resistance to the passage of an accumulated current.

Various forms of apparatus exist in a portable form from which accumulated currents may be obtained for the ignition of the torpedo, but for practical service the portable magneto-induction coil apparatus, arranged by Professor Wheatstone, has a decided advantage over both the voltaic apparatus, with its cumbersome chemical details, and the ebonite plate frictional machine.

By thus employing "intensity" currents for testing, and "accumulated" currents for the instantaneous discharge of the mines, that control and security is obtained in the manipulation of the torpedo, so essential to render it a safe and reliable defence, and one of the most deadly and destructive engines of modern warfare. Various mechanical arrangements have been introduced in connection with the system to indicate at the observing stations any attempts on the part of the enemy to destroy the mines or connections. The power of passing intensity currents continuously through the circuits has been made available to give alarm, by the ringing of bells, of any interruption of the circuits, and at the same time indicate the particular point of injury. Guns can likewise be kept loaded in position to rake each line of defence at night, should the enemy, under cover of darkness, attempt to drag for torpedoes. These, and many other valuable practical arrangements, have been included in the new system of torpedo defence.

It has not been my intention, in the present paper, to give any very accurate details of the apparatus or working arrangements in connection with the establishment of the new defence, but simply to state in

a general way the progress made, and the outline of principles which have governed the brilliant discoveries made in adapting this most formidable engine of destruction to the exigencies of naval and military defence.

Of course, it is impossible, in condensing a description of the torpedo defence into an hour, to give the mechanism of the letails, or the arrangements at the station, or, in fact, any of the rules by which the resistances at the bridge are determined, or the weights or charges of powder in relation to the water cushion. Those are subjects which are not in the department of the electrical engineer; they are more in the department of the naval and military engineer.

Captain HOUSTON STEWART, R.N.: I should like to ask a few questions of Mr. Holmes, as he has had great experience in experiments with torpedoes, a subject which attracts great interest among naval and military officers, viz., what sort of powder ought to be used for torpedoes? Whether it should be slow-burning powder or quick-burning powder? Then I should also like to ask whether he attaches any importance to having an air-chamber in the torpedo or not? Whether he thinks there should be any diaphragm to separate the charge? Whether he attaches importance to any particular form of torpedo? Whether he thinks it important that the torpedo should be of metal, or whether it should be of india-rubber? Whether these points are of any importance in the construction of torpedoes?

Mr. HOLMES: As far as regards the use of gunpowder, or gun-cotton, or nitro-glycerine, it is a matter which at present requires further investigation. Certainly, this may be said, that the explosive effect of gun-cotton is much cleaner. It does not allow sufficient time for the elasticity of the water to come into play. But then in using gun-cotton for ground torpedoes, you have the disadvantage of the buoyancy of the gun-cotton. You have to load your torpedoes to make them sink; whereas, by using a much larger weight of gunpowder, proportionate to the difference of the explosive effects of the two compounds, you add to the stability of the mine when ground torpedoes are under consideration.

Captain HOUSTON STEWART: I did not wish to touch upon the question of gun-cotton for the charge. I merely asked if you thought it important what sort of powder should be used—whether it should be quick-burning or slow-burning powder? whether that had any great effect upon the action of the torpedo?

Mr. HOLMES: I am hardly able to answer that question myself; but Captain Maury, who is present, and, perhaps, knows more about that question than I do, might give a better answer. My department has been the construction and carrying out the system, to enable the naval and military engineer to use it. The experience of the Confederate officers in torpedoes is well known, and Captain Maury, I think, would at once state what he knows upon the subject.

Captain MAURY: That is precisely one of these points upon which we want experiment, and for results of which I have been looking, with a great deal of interest, to the experiments by Her Majesty's Government. As far as experience goes, the results of experiments, conducted in Austria by Baron Ebner, award the preference to gun-cotton over gunpowder, because of its quick burning and explosive force; in his torpedoes, diaphragms were left to give room for the charge to explode. But the experiments are not in favour of india-rubber, or any such light material as a casing; on the contrary, something strong enough to resist explosion until the explosive matter has fairly time to ignite, is required. The torpedoes in the James River, which were so successfully employed there, were made of boiler-plate iron. We had no gun-cotton, and they were filled with gunpowder and laid on the bottom. With regard to the difficulty that has occurred with the fuze (which was subsequently ascertained to have arisen entirely from moisture entering the connections and interfering with the insulation), it illustrates a conversation I have had with Mr. Holmes since my arrival in England. When

I commenced these experiments in 1863, in England, I was very much impressed with the importance of having a fuze through which you could send a feeble current of electricity, in order to feel and know that all was right with the torpedo. I found that some of the fuzes which had been prepared by Mr. Abel, of Woolwich, and which were the fuzes of commerce, would pass a feeble current of electricity. But in order to ascertain that the passage of the current, for testing purposes, would not damage the fuze, I got a friend to put one of those fuzes under a weak current, with a view of letting it stay there several days. He said, of course, if it passes the current once, it will pass it always, and there will be no difficulty about it. The next morning, however, I got a note from him to say that, after it had been under a weak battery for ten or twelve hours, it exploded. That fuze, when you came to the composition of it, was known as the phosphide fuze. Mr. Abel was then asked to make a fuze which would be as explosive as the phosphide fuze, but which would pass a current without the danger of explosion. He made me such a fuze, and before I went away he furnished me with samples of three kinds of such fuzes for trial. With those fuzes I do not think it possible to have such an accident as that which has occurred to-night. Because, like the old captain of a gun, inserting his priming wire to feel if his cartridge was home, when we send a current of electricity through the fuze, we know that all is right, and that is the last thing we do before putting the fuze into the torpedo. Then it is closed up, and the circuit is used no more. I find now, that the fuzes of commerce are not those fuzes; they do not pass with equal certainty a weak galvanic current. That is the difficulty, because those fuzes are liable to be jarred, and the priming liable to be displaced. I think the fuzes, considering their importance, should not only be of glass, but they should be of the composition of the fuze that Mr. Abel made—I mean the fuze he made at my request through Mr. Holmes, which would pass a current of electricity without firing the phosphide, or any other ingredient of the fuze, that would be liable to explosion. That is the fuze we want. Referring again to diagrams iv. and v. which Mr. Holmes has so well drawn and explained, I should say that they possess other advantages, which no doubt he omitted to mention for want of time. Now, suppose an enemy should come at night, and drag up those wires, and cut one of the wires as B D, the torpedo could still be exploded; and, in order that it should not be exploded, he must also cut the wire A D. He must cut the wire on both sides of the torpedo. Then, by laying those wires carefully, we can, in very dark, foggy weather, when it is impossible to see, though the enemy may come and cut that wire B D, or any other, have a bell to ring which will give an alarm, or we may cause the cutting of the wire to fire a gun trained along the line of that wire. Here we have one of the best protections that you can possibly conceive for preventing those torpedoes from being interfered with by an enemy in the darkness of the night, or by boats. Generally, we can manage to have an electrical light to be thrown in a particular direction; because, when your bell rings, you know to which wire it belongs, consequently you know where the enemy is disturbing the wires. I think it is impossible to bring sea-mining to the state in which you have seen it represented to-night without those two instruments on the table—Wheatstone's Magneto Telegraph and the frictional battery, arranged by Baron Ebner, and known as the Ebnerite machine.

Mr. LADD: I do not like the mode Mr. Holmes has adopted for testing Abel's fuzes. One great object in the manufacture has been to make a fuze that shall explode with a small amount of electricity; but by placing Mr. Holmes' bridge across the wire its sensitiveness is entirely removed. As a proof that Abel's fuzes can be depended upon, I may say they have been used by the River Tyne Commissioners for their time gun for the last two years, and I am not aware of a single failure.

Mr. HOLMES: The object of the bridge is not to test the fuze. The fuze is supposed to be tested before it is placed in the torpedo. The object of the bridge is to test the torpedo circuits themselves; to ascertain that the connections between the stations, and through the torpedo, are in perfect order. When the fuze, once perfectly made, is enclosed in the torpedo-tank, it no longer requires testing. But the connections between the shore and the torpedo are every minute liable to

derangement by abrasion, by currents, by boats, by the enemy's grappling. Therefore, the bridge arrangement is to enable such a test to pass through your conductor as will ensure the integrity of the line of circuit; it is not in any way connected with the test of the fuze.

Mr. OWEN ROWLAND: I have now had experience in electricity for many years, and I must confess that the arrangements of Mr. Holmes seem to be the most perfect that I have ever read of, or have ever myself seen. There is great novelty and practical utility in them. The action cannot be otherwise than perfect. The arrangements for firing are quite new to me. I am well acquainted with all the different fuzes introduced by Mr. Abel; and certainly, this arrangement of Mr. Holmes for communicating through the torpedoes, by which you are always certain that they are in proper order, appears to me very valuable. I can say, as an old electrician, that I am very glad to see it introduced as Mr. Holmes has introduced it.

The CHAIRMAN: I have now the agreeable duty, to return our thanks to Mr. Holmes, for one of the most interesting lectures we have had in this theatre. The subject has been so well put before us, and made so plain to the comprehension of many who have not had the opportunity of mastering the details, that we are doubly indebted to him, not only for the subject itself, but for the way in which he has put it before us. I should not like the evening to close without including Captain Maury in this vote of thanks, for his kindness in contributing to the explanation of the subject.

LECTURE.

Friday, May 25th, 1866.

GENERAL H.R.H. THE PRINCE OF WALES, K.G., K.S.I.,
Vice-Patron, in the Chair.

GUN-COTTON AND OTHER EXPLOSIVE AGENTS.

By F. A. ABEL, Esq., F.R.S., Chemist to the War Department.

ABSTRACT.

The changes which have been effected in the composition of gunpowder since its first application as a propelling agent, have been limited to small variations in the proportion of its components. But the modifications which have, from time to time, been introduced into the details of its manufacture, *e.g.*, the preparation of the ingredients, their incorporation, and the conversion of the mixture into compact masses (grains, &c.) of different size and density, have been sufficiently important and successful to secure the fulfilment by gunpowder, in a more or less efficient manner, of the very various requirements of military science, and of different branches of industry.

The characteristics of gunpowder, as an explosive material of permanent character, the action of which is susceptible of great modification, are mainly ascribable to the peculiar properties of the oxidising agent—saltpetre. Frequent attempts have been made to replace this constituent of gunpowder by other nitrates (such as those of sodium, lead, and barium), but, although materials suitable for blasting operations have been thus prepared (such as soda-gunpowder, and barytic powder, or *poudre saxifragine*), all mixtures of this class, hitherto produced, have exhibited important defects, when compared with gunpowder manufactured for propelling purposes.

The well-known oxidising agent, chlorate of potash, which differs from saltpetre only in containing chlorine in the place of nitrogen, is

far more energetic in its action upon oxidisable bodies than any of the nitrates. Thus, a mixture of chlorate of potash with charcoal alone, deflagrates as violently as gunpowder, and is far more readily inflamed by percussion than the latter, while a mixture analogous to gunpowder, containing chlorate of potash in place of saltpetre, detonates violently when struck with moderate force, and acts far too destructively, on account of the rapidity of its explosion, to admit of its safe employment in fire-arms.

Many years ago a mixture, known as German or white gunpowder, and consisting of chlorate of potash, ferrocyanide of potassium, and sugar, was proposed, and tried without success, as a substitute for gunpowder, and since then, many preparations of similar character have been suggested for employment, either as blasting and mining agents, or for use in shells, or even for all the purposes to which gunpowder is employed. The most promising of these, claimed as discoveries by Mr. Horsley and Dr. Ehrhardt, are mixtures of chlorate of potash with substances of permanent character and readily obtained, containing both carbon and hydrogen, such as tannic and gallic acids, and some kinds of resins. These mixtures are much less violently detonating than most of the explosive mixtures containing chlorate of potash, while, if well prepared, they are decidedly more powerful as explosives than gunpowder. For blasting purposes, some of these mixtures probably possess decided advantages over ordinary blasting powder, and possibly they may also be susceptible of employment for sporting purposes; but they are not applicable to fire-arms used for war purposes, because in order to ensure the requisite uniformity of action, the ingredients must be submitted to proper processes of incorporation, such as are applied to the manufacture of gunpowder, and this treatment would render the mixtures far more violent, and consequently destructive, in their action upon fire-arms, than if they were used in the form of crude mixtures.

A comparatively very safe application of chlorate of potash to the production of a substitute for gunpowder was made about six years ago by a German chemical manufacturer, M. Hochstädter. Unsized (blotting) paper was thoroughly soaked in, and coated with a thin paste consisting of chlorate of potash, finely-divided charcoal, a small quantity of sulphide of antimony, and a little starch, gum, or some similar binding material, water being used as the solvent and mixing agent. The paper was rolled up very compactly and dried in that form. In this manner, very firm rolls of an explosive material are obtained, which burns with considerable violence in open air, and the propelling effect of which, in small arms, has occasionally been found greater than that of a corresponding charge of rifle powder. Moreover, the material, if submitted in small portions to violent percussion, exhibits but little tendency to detonation. But, as no reliance could be placed on a sufficient uniformity of action in a fire-arm, of these explosive rolls, this alone sufficed to prevent their competing with powder. The same description of explosive preparation, differing only from that of M. Hochstädter in a trifling modification of its composition, which is certainly not likely to lead to its greater success, has

recently been brought forward in this country by M. Reichen and T. W. Melland.

One or two other much cruder explosive preparations, containing chlorate of potash, alone or in conjunction with saltpetre, have received some application to blasting purposes. One of these consisted of spent tan, in small fragments, which was saturated with the oxidising agent, and afterwards dusted over with sulphur. When flame or a red-hot iron is applied to this preparation, it deflagrates very slowly and imperfectly, but when employed in blast-holes, where it is confined within a small space, it developes sufficient explosive force to do good work. In addition to comparative cheapness, the great advantage of safety was claimed for this material by its inventor—a claim which was substantiated by the partial destruction by fire, on two occasions, of a manufactory of the substance near Plymouth, without the occurrence of an explosion.

One of the most remarkable materials recently employed to replace gunpowder as a destructive agent, is *nitroglycerine*. This substance was discovered by Sobrero in 1847, and is produced by adding glycerine in successive small quantities to a mixture of one volume of nitric acid of specific gravity 1·43, and two volumes of sulphuric acid, of specific gravity 1·83. The acid is cooled artificially during the addition of glycerine, and the mixture is afterwards poured into water, when an amber-coloured oily fluid separates, which is insoluble in water, and possesses no odour, but has a sweet, pungent flavour, and is very poisonous, a minute quantity, placed upon the tongue, producing violent headache, which lasts several hours. The liquid has a specific gravity of 1·6, and solidifies at about 5° C. (40° F.) If flame is applied, nitroglycerine simply burns, and if placed upon paper or metal, and held over a source of heat, it explodes feebly after a short time, burning with a smoky flame. If paper, moistened with it, be sharply struck, a somewhat violent detonation is produced.

Alfred Nobel, a Swedish engineer, was the first to attempt the application of nitroglycerine, as an explosive agent, in 1864. Some experiments were, in the first instance, made with gunpowder, the grains of which had been saturated with nitroglycerine. This powder burned much as usual, but with a brighter flame, in open air. When confined in shells or blast-holes, greater effects were, however, produced with it than with ordinary gunpowder; its destructive action is described as having been from three to six times greater than that of powder. The liquid could not be employed as a blasting agent in the ordinary manner, as the application of flame to it from an ordinary fuze, would not cause it to explode. But Mr. Nobel has succeeded, by employing a special description of fuze, in applying the liquid alone as a very powerful destructive agent. The charge of nitroglycerine having been introduced, in a suitable case, into the blast-hole, a fuze, to the extremity of which is attached a small charge of gunpowder, is fixed immediately over the liquid. The concussion produced by the exploding powder upon ignition of the fuze, effects the explosion of the nitroglycerine. The destructive action of this material is estimated, by those who have made experiments in London and Germany,

at about ten times that of an equal weight of gunpowder. Therefore, although its cost is about seven times that of blasting powder, its use is stated to be attended with considerable economy, more especially in hard rocks, a great saving being effected by its means in the labour of the miners and in the time occupied in performing a given amount of work, as much fewer and smaller blast-holes are required than when gunpowder is employed. The material appears to have recently received considerable application in some parts of Germany and in Sweden; but, in England, its employment has been confined to one set of experiments instituted in Cornwall last summer, upon which occasion a wrought-iron block, weighing about 3 cwt., was rent into fragments by the explosion of a charge of less than one ounce of nitroglycerine, placed in a central cavity.

Nitroglycerine appears therefore to possess very important advantages over gunpowder as a blasting and destructive agent, but the attempts to introduce it as a substitute for gunpowder have already been attended by most disastrous results, ascribable in part to some of its properties and the evident instability of the commercial product; but principally to the thoughtlessness of those interested in its application, who appear to have been induced, either by undue confidence in its permanence and comparative safety, or from less excusable motives, to leave the masters of ships, or others who had to deal with the transport of the material, in ignorance of its dangerous character.

The precise causes of the fearful explosions of nitroglycerine which occurred at Aspinwall and San Francisco will, in all probability, never be ascertained, but they are likely to have been due, at any rate indirectly, to the spontaneous decomposition of the substance, induced or accelerated by the elevated temperature of the atmosphere in those parts of the ships where it was stored. Instances are on record in which the violent rupture of closed vessels containing commercial nitroglycerine has been occasioned by the accumulation of gases, generated by its gradual decomposition; and it is, at any rate, not improbable that a similar result, favoured by the warmth of the atmosphere, and eventually determined by some accidental agitation of the contents of a package of nitroglycerine, was the cause of those lamentable accidents. The great difficulties attending the purification of nitroglycerine upon a practical scale, and the uncertainty as regards stability of the material, even when purified (leaving out of consideration its very poisonous character and its extreme sensitiveness to explosion by percussion in the solid form), appear to present insurmountable obstacles to its safe application as a substitute for gunpowder.

The conversion of purified lignin, or wood-fibre, into an explosive substance of the same nature as gun-cotton, was accomplished by chemists soon after Schönbein's discovery of gun-cotton was made known. Finely-divided wood or sawdust may, by treatment with suitable agents, be to a very considerable extent purified of substances foreign to cellulose, and if then submitted to careful treatment with a mixture of the strongest nitric and sulphuric acids, and properly purified, it furnishes a highly explosive material similar to the most explosive

gun-cotton, and possessed, apparently, of considerable stability. Captain Schultze, a Prussian artillery officer, who was entrusted by his Government, a few years ago, with the investigation of gun-cotton, appears to have come to the conclusion that finely-divided wood offered greater prospect of conversion into a controlable explosive agent than cotton-wool. The ultimate results of his investigations has been the production of a "*gun-sawdust*," the explosive properties of which depend in great measure upon its impregnation with a considerable proportion of an oxidising agent, either saltpetre or a mixture of that salt and nitrate of baryta. The wood having been reduced to a tolerably uniform state of division, is submitted by Captain Schultze to purifying processes, for the separation of resinous and other substances from the lignin, and the product is converted, by digestion in a mixture of sulphuric and nitric acids, into a very feebly-explosive material, which leaves a considerable carbonaceous residue when burned. This product, after purification, is impregnated with a sufficient proportion of nitrates to give it rapidly explosive power, the oxidation of the carbon being now almost complete.

The objects which appear to be aimed at by Captain Schultze in following this method of manufacturing a wood-gunpowder, are, the production of a more gradually explosive material than is obtained by the most perfect action of nitric acid upon wood-fibre, and the possibility of preserving the material in a slightly explosive and therefore comparatively harmless form, until it is required for use, when it may be soon rendered powerfully explosive by impregnation with the nitrates. It is asserted that this powder is considerably more powerful than gunpowder as a mining agent, and that by its employment in mines, the operators are enabled to return to work sooner than when gunpowder is used, because there is little or no smoke produced by its explosion. The latter is an undoubted advantage, which Schultze's powder shares with gun-cotton. Advantages are also claimed for this material when employed in fire-arms, and it is possible that, when applied to sporting purposes, it may compete successfully with gunpowder in this direction also; but its behaviour as an explosive, and the peculiarities of its structure, afford little promise of its advantageous employment in arms for military and naval purposes.

Important progress has been made in the history and the practical application of gun-cotton since its study was resumed in this country, about three years ago. Very considerable quantities of the material have been manufactured at the works of Messrs. Prentice, at Stowmarket, and at the Government gunpowder works at Waltham Abbey. Its application to mining and artillery purposes and to small arms has been, and is still, the subject of systematic experiments, conducted by the Government Committee on Gun-cotton; its employment as a blasting agent is steadily increasing in several important English mining districts; and considerable, though not uniform, success has already attended the employment of gun-cotton cartridges for sporting purposes.

The system of manufacture of gun-cotton, as perfected by Baron von Lenk, has undergone but trifling modifications in its employment in this country. It has been made the subject of careful investigation by

Mr. Abel; and the results furnished by many experimental manufacturing operations, and an examination of the products, have shown that the processes of converting cotton into the most explosive form of pyroxylin or gun-cotton, and of purifying the material, have been so greatly perfected by v. Lenk as to render a strict adherence to his simple and precise instructions alone necessary to ensure the preparation of very uniform products, which exhibit in their composition a very much closer approximation to purity than those obtained in the earlier days of the history of gun-cotton.

Although the conclusions arrived at by the many chemists who investigated the composition of gun-cotton soon after Schönbein's discovery varied very considerably, the constitution has been very generally regarded as definitely established by the researches of Hadow, published in 1854. According to that chemist, the most explosive gun-cotton has the composition expressed by the formula $C_6H_7N_3O_{11}$ (which was first assigned to the substance by Mr. Crum in 1847), and may be regarded as cellulose, in which three atoms of hydrogen are replaced by three molecules of peroxide of nitrogen. The name *trinitro-cellulose* has therefore been assigned to gun-cotton, its constitution being expressed by the formula $C_6\left\{\begin{matrix} H_7 \\ 3NO_2 \end{matrix}\right\}O_5$.

Hadow's conclusions have since been confirmed by other chemists, more especially by Redtenbacher, Schrötter, and Schneider, who have analysed specimens of gun-cotton prepared under v. Lenk's directions. But a report upon the Austrian gun-cotton was published, in 1864, by Pelouze and Maury, in which the formula $C_{24}H_{36}O_{18},5N_2O_5$ is assigned to the product of v. Lenk's process, the conclusions of those chemists being founded partly upon some analytical results and partly upon the increase of weight which they found cotton to sustain, when submitted to treatment with the mixed acids. They observed the greatest increase in weight to be 78 per cent., a number slightly in excess of that which would correspond to the requirements of the formula which they adopt.

An experimental inquiry into the composition of gun-cotton, as obtained by v. Lenk's process has been instituted by Mr. Abel, and the very numerous analytical and synthetical results which he had obtained, confirm the correctness of the formula assigned by Crum and Hadow to the most explosive gun-cotton, and demonstrate satisfactorily that the products obtained by following strictly the instructions given by v. Lenk, are invariably trinitro-cellulose, in a condition as nearly approaching purity as a manufacturing operation can be expected to furnish.

The most explosive gun-cotton is perfectly insoluble in mixtures of ether and alcohol; but, by varying the proportions and strength of the acids employed for the conversion of cotton, products of less explosive character are obtained, which are more or less freely soluble in ether and alcohol (furnishing the well-known material *collodion*). If, therefore, in manufacturing gun-cotton, the conditions essential to the production of insoluble pyroxylin are not most strictly fulfilled, the uniformity of the product will suffer.

The ordinary products of manufacture are never altogether free from soluble gun-cotton, but the proportion present is small and very uniform, amounting to about 1·5 per cent. They contain, besides, a small quantity (about 1·5 per cent.) of matter soluble in alcohol alone, and possessed of acid characters, which is evidently produced by the action of nitric acid upon such small quantities of resinous or other matters foreign to pure cellulose as are not completely removed from the cotton fibre by the purification which it receives. There appears good reason to believe that this impurity in gun-cotton is of comparatively unstable character, and that the great proneness to spontaneous decomposition, which has been observed by Pelouze and Maury, De Luca, and others, in some specimens of gun-cotton, is to be ascribed in great measure to the existence, in those specimens, of comparatively large proportions of these unstable bye-products.

One hundred parts of carefully purified cotton-wool have been found by Mr. Abel to furnish from 181·8 to 182·5 parts of gun-cotton. The increase which *perfectly pure cellulose* should sustain by absolutely complete conversion into a substance of the formula $C_6H_7N\,\Theta$ (*trinitro-cellulose*) is 83·3; the above results are, therefore, strong confirmations of the correctness of this generally accepted view of the composition of gun-cotton. In carrying out the actual manufacturing process as prescribed by v. Lenk, somewhat lower results are obtained, because of impurities existing in the cotton employed, and of loss of product during its purification.

Very extensive experiments are in progress at Woolwich with the view of examining fully into the extent of liability to change of gun-cotton, when preserved in store, or exposed for prolonged periods to light, and to degrees of heat ranging between the ordinary atmospheric temperatures and that of boiling water. The results hitherto arrived at, though they have shown that, under very severe conditions, gun-cotton is liable to decompose, have not confirmed the conclusions arrived at by the French chemists with regard to the great instability of the material. Thus, De Luca states all specimens exposed by him to sunlight decomposed either on the first day, or within a few days. But, at Woolwich, no single instance of such rapid decomposition of gun-cotton made by the present process has been noticed.

A very gradual and slight development of gas occurs after a time, when the substance is exposed to sunlight, but the quantity which has been collected from specimens exposed at Woolwich to direct day and sun light for 2½ years is very small, and the gun-cotton has in all instances preserved its original appearance. Pelouze and Maury state that gun-cotton always decomposes perfectly within a few days by exposure to temperatures of 55°—60° C. (130°—140° F.), and they lay great stress upon the explosion of a specimen directly it was introduced into a vessel heated to 47° C. (116°·6 F.). But at Woolwich a specimen of ordinary produce, which has been exposed now for 12 months to 65° C. (150° F.), has evolved only a small quantity of gas, and retains its original appearance perfectly. Several specimens, after having been exposed for some days to a temperature of 90° C. (194° F.), during which period some nitrous vapours were in all instances evolved, have

since been exposed to light in closed vessels for about 20 months, and still retain their original appearance and explosive characters.

Several large ammunition cases, closely packed with gun-cotton, have been preserved for six months in a chamber, the temperature of which was maintained for three months at 49° C. (120° F.), and afterwards at 54—55° C. (130° F.), arrangements having been made for periodically registering the temperature within the boxes, which were kept closed. In no instance has the latter temperature risen to an extent to indicate serious chemical change, *i.e.*, it has always been below the temperature of the air in the chamber. These few examples of results already obtained are given to show that the behaviour of gun-cotton manufactured in England by v. Lenk's process does not as yet at all justify the condemnation which the material has recently received in France.

One most important point in connection with the preservation of gun-cotton appears to have been lost sight of by the French experimenters. The material may be most perfectly preserved, apparently, for any period, either by immersion in water, or, still more simply, by being impregnated with just sufficient moisture to render it perfectly uninflammable. In this condition gun-cotton is much safer than gunpowder can be rendered by mixture even with very large proportions of incombustible materials. It may be transported with quite as much safety as the unconverted cotton; indeed, it appears to be very much less prone to gradual decay, if preserved for very long periods in a damp condition, than cotton or other vegetable substances. Numerous specimens of gun-cotton, preserved for many months in a very damp chamber, together with paper, cotton fabrics, and wood, retained their strength of fibre and all the original properties, and had no signs even of mildew upon them; while the paper and fabrics, in immediate contact with it, had completely rotted away, and the wood was covered with fungi.

Considerable progress has been made in the manipulation of gun-cotton, with the object of modifying its explosive action. The rapidity with which gun-cotton burns *in open air* admits of ready and very considerable variation, by applying the simple expedients of winding, twisting, or plaiting gun-cotton yarn of different sizes. But although a mass of gun-cotton may be made to burn in a comparatively gradual manner by being very tightly wound, a charge of the material, in that form, acts quite as destructively, when exploded in the bore of a gun, as an equal charge consisting of the yarn wound very loosely, because the pressure of gas established by the first ignition of the charge renders the compact packing of the gun-cotton powerless to resist the instantaneous penetration of flame between the separate layers of the material. The assertion that a power had been acquired of controlling the explosive action of gun-cotton in a fire-arm, by simply varying the compactness with which the material was twisted or wound, has therefore proved quite erroneous.

There are, however, two methods of reducing the rapidity of explosion of gun-cotton, which are much more likely to furnish successful results. The one consists in diluting the material, by its admixture

either with a less explosive variety of gun-cotton, or with some unexplosive substance, such, for instance, as the cotton in its original form. The latter mode of dilution has recently been applied by Messrs. Prentice to the construction of cartridges for sporting purposes, and they describe the results already arrived at as very promising. The second method of controlling the explosion of gun-cotton consists in consolidating the material, by pressure, into compact homogeneous masses, and in confining the first ignition of such compressed gun-cotton in the bore of the guns to certain surfaces.

The gun-cotton fibre, in the form of yarn or plait, may be compressed into very compact masses, by being rammed into strong cylinders of pasteboard or other suitable material, but much more perfectly homogeneous and solid masses are produced, independently of cylinders or other cases, by a method which Mr. Abel has recently elaborated, and which consists in reducing the gun-cotton fibre to a fine state of division, or pulp, as in the process of paper-making, and in converting this pulp by pressure into solid masses of any suitable form or density. This method of operating affords also special facilities for combining both methods, dilution and compression, of reducing the explosive violence of gun-cotton. The material is, in fact, operated upon by this system in a manner exactly corresponding to the processes by which the explosive action of gunpowder is regulated to so remarkable an extent. Some results, which are admitted by the most sceptical as encouraging, have already been arrived at in the systematic course of experiments which are in progress, with the object of applying the methods of regulation pointed out, to the reduction of gun-cotton to a safe form for artillery purposes.

Its arrangement in a form suitable for small arms is a much less difficult problem, which may be considered as approaching a perfect solution. For employment in shells and for military mines, both land and submarine, the compressed or solid form of gun-cotton presents special advantages, on account of the great compactness which may be imparted to it; a given weight, arranged so as to ignite instantaneously under pressure (*i.e.*, in strong vessels), may be made to occupy the same space as an equal weight of gunpowder, whereas the forms of gun-cotton hitherto applied to these purposes occupy about three times the space of gunpowder.

Beautiful pyrotechnic effects may be readily produced by means of gun-cotton, though the absence of smoke, which in some of its applications (especially in mines) would constitute an important advantage, detracts from some of the effects which may be obtained with ordinary pyrotechnic compositions. On the other hand, gun-cotton fireworks may be displayed indoors without inconvenience.

There appears at present no reason to doubt that the application of gun-cotton, with great advantage to at least some of the more important purposes for which gunpowder is used, will, ere long, be fully established, and that this interesting explosive agent is destined to occupy a permanent and prominent position among the most important products of chemical industry.